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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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AMERICAN WELDING SOCIETY
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JOURNAL

Volume 2 OCTOBER, 1923 Nnmber 10

SOCIETY AFFAIRS

T. F. Barton, President

Relation of the Society to the Manufacturers of Welding Apparatus. Members of the Society will no doubt be glad to know of the close co-operation existing between manufacturers of welding apparatus and the Society. As evidence of this, I wish to point out some of the ways in which these manufacturers have supported the Society.

a. With a few exceptions every apparatus company of any magnitude is now advertising in the Journal.
b. From time to time these companies have purchased from 25 to 500 copies of the Journal for general distribution throughout their organization and to their customers.
c. They have referred to the various standards adopted by the Society and have quoted them as being authoritative.

Finances. The finances of the Society are in good condition. I make this statement not to have you feel that we are so situated financially that we need no further assistance for with increased funds the activities of the Society can be expanded along the following lines:

a. Circulars of promotion can be issued which would better acquaint the entire industrial world with what we are already doing.
b. The size of the Journal can be increased.
c. Additional research work can be undertaken.

Membership. At present our membership is not as large in number as one would naturally expect but our members are in good standing and we are not carrying any "deadwood." If we had not dropped members for delinquency from time to time we would have more than 1,000 members today, but even this number is not what it should be. We should have at least 2,000. I mention this in order that the members may realize that each and every one must play his part in securing new members. This will mean a more healthy condition of the Society and at the same time provide funds to increase our activities.

Journal. No doubt you are all receiving the Journal each month. Many favorable comments have been received both from abroad and this country regarding the articles and reports published in our Journal. The value of this can be increased with increased membership.

Promotion. In this connection, I would like to state that it is more important at first to spread broadcast information already available and to give encouragement and assistance to those now doing welding who have difficult problems to solve, than it is to attempt to educate those not doing it. The fact that we receive regularly many inquiries for welding information from all parts of the world is an indication of the confidence the industry now has in the Society.

ADVERTISING AND MEMBERSHIP DUES

Our readers have been no doubt gratified to note that the Journal of the Society now includes the advertisements of most of the companies manufacturing welding apparatus and supplies which is fitting recognition of the merits of the Journal as an advertising medium. The Journal is now recognized as the greatest authoritative source of welding information in this country and is saved as a permanent record. Aside from a tangible return from advertising there is a still greater indirect return which is not always apparent. This return comes about through the fact that the revenue secured by the Society through advertising and membership

goes to the promotion of the art of welding, the extension of its applications and the dissemination of authentic information. It is a well known fact that the applications of welding during the past few years have more than trebled. A large part of this is unquestionably due to the efforts of the American Welding Society. The increased use of welding means more business for the manufacturers of welded products and of welding apparatus and supplies. More revenue would likewise enable the Society to further increase its service to the welding industry.

The same reasoning applies to membership dues and the number of members. Aside from the actual money received as dues progress by the Society depends in a considerable measure on the number of its members. More members means there are more people who are making a serious effort to secure the most reliable information on welding which in turn must result in greater progress both as to quantity and quality. More members also enables us to draw on more people for this information and experience and adds to the value of the Journal as an advertising medium. The revenue itself allows us to carry on more research work which is needed for the solution of many difficult problems and for convincing executives and legislators of the adequacy of welding.

Our membership should be at least twice as large as it is. If each member were to realize that this is his Society and that he is in part responsible for its success; that any service to the Society is a service to the industry which helps him to make a living and that the healthy growth of the welding industry means greater opportunity for his personal development and advancement, the Society would treble its membership in one year.

BRITISH WELDING SOCIETY MAKES PROGRESS

The "Institution of Welding Engineers," with headquarters at 30 Red Lion Square, Holborn, London, W. C. I., is making headway. At present it has 110 members divided equally among welders and members of firms engaged or interested in the welding and allied industries.

The first corporate meeting will be held on October 10th at which time President Sir W. Peter Rylands, J. P., will deliver an address on the "Aims and Objects of the Institution." These aims are briefly to undertake co-operative research in solving welding problems and to disseminate the information and experiences of technical welding experts and practical welders. The American Welding Society wishes the British Society success in its undertaking.

WELDED RAIL JOINT ACTIVITIES

Members of the Society are already familiar with the work of the Welded Rail Joint Committee. This Committee working in conjunction with A. E. R. A. and the various street railways has undertaken to make an authoritative investigation on the various types of welded rail joints in commercial use with the expectation of improving each type. The solution of the problems involved requires co-operation on a large scale. Electric railway companies all over the country are installing thousands of joints every year; in many cases using methods and variations in processes which have been tried elsewhere and found unsatisfactory, or the ultimate effects of which are entirely unknown. The Committee has designed two testing machines, one of them to give the test joints repeated impact blows of a magnitude equal to that given by a trolley car in passing over a cupped joint. The other is a rotary service testing machine designed to simulate service wear. The repeated impact testing machine has already been built and shipped to the Bureau of Standards.

Testing has been started on a number of test joints made by the street railway companies and joint manufacturers to determine the "present state of the art." The tensile tests are being made by the Bureau of Standards and auxilary heads were designed to grip the specimens in their large Emery testing machine without machining the ends. The bend and drop tests are being made at Purdue University and University of Illinois, respectively.

A meeting of the Committee will be held in Atlantic City on October 10th, during the Convention of the A. E. R. A. At this meeting test data ob-

tained to date will be carefully reviewed and a program for future activities outlined. The present investigations involve a sum of the order of $80,000. Co-operation has been offered from all sides to the Committee. Rail manufacturers are furnishing the rail for test purposes, electric railway companies and joint manufacturers are making the joints, and the various laboratories mentioned above are doing the testing. $24,000 in cash has been placed at the disposal of the Committee.

JOURNAL

As the Editor, I have been asked to say a few words about the Journal of the Society. As you are already aware, the Journal is a paying proposition from a financial viewpoint and is in fact netting the Society an appreciable revenue which should be increased as time goes on. Most of the leading manufacturers of welding apparatus and equipment are now regularly using the Journal as a medium for advertising. Those who have checked up their source of sales inform me that this advertising is a paying proposition which, of course, is very pleasing. Aside from the direct revenue which these manufacturers derive as a result of this advertising a still greater profit accrues to them from the increased use of welding brought about through the efforts of the Society and its research department, the American Bureau of Welding. The entire revenue of the Society is devoted to the advancement of welding and the dissemination of authentic information.

The Meetings and Papers Committee have been gratified to receive during the last year letters of appreciation and praise for the Journal from many countries. The Committee is succeeding in making the Journal recognized as the most authoritative source of welding information in the world. It can only continue to do so, however, through the hearty support of the members of the Society. The support which you can render is not something which is intangible, but consists of furnishing suitable articles dealing with welding and its applications. We would like to have more descriptions of difficult welding jobs accompanied by suitable illustrations and the necessary technical information which would enable a job to be duplicated. We would also like to include more articles showing applications of welding in manufacturing processes, accompanied by technical data, cost, comparison of the advantages of fabrication by welding versus other processes. Perhaps you are a manufacturer who is using welding daily in your work. To you it may have become a routine job. To others if they have the information it might be a source of an idea, an inspiration of how it might be applied in their particular work.

Again, you may have sometime or other made tests to determine the adequacy of welding as applied in your work. Whether the results of these tests have been favorable or not we should like to have a complete description of them, as this is one way to disseminate information through which the art and knowledge of welding may be advanced in a few months equivalent to years of single effort.

My message is therefore to call your attention to the fact that there exists through the Journal of the Society a source for the dissemination of welding information and it is our hope that you will make the best use of it. On the other hand, if you have some welding problems which you cannot solve yourself, the American Bureau of Welding stands ready to help you to the maximum limit of its ability and if the information obtained for your use is found suitable it will be given to the industry through the Journal.

W. Spraragen, Editor.

A. S. M. E. FEATURES WELDING

The program for the first regional meeting of the South of the A. S. M. E. will be held in Chattanooga on October 23rd and 24th. The entire session on Tuesday morning is given over to welding. The following papers will be presented at that time:

Welding in Locomotive Repair Shops, Fred E. Rogers; Welding Pressure Vessels and Pipe Lines, S. W. Miller; Arc Welding, R. D. Reed; Motion Picture, "Oxygen the Wonder Worker."

In arranging the session on welding the consideration of practical applications has been featured as being of greatest value to engineers who will attend the meeting. As two papers deal with gas welding and one

with electric there is a nucleus for discussion of the respective merits of the two methods for different purposes. The speakers for this session, Fred E. Rogers, of the Air Reduction Sales Company, New York; S. W. Miller, of the Union Carbide and Carbon Research Laboratories, Long Island City, N. Y., and R. D. Reed, of the General Electric Company, Schenectady, N. Y., are particularly well informed on their subjects. The motion picture film entitled "Oxygen the Wonder Worker," is to be shown by Professor A. S. Kinsey, of Stevens Institute of Technology, and the Air Reduction Sales Company. The session was arranged with the co-operation of the A. S. M. E. Machine Shop Practice Division.

Section Activities

NORTHERN NEW YORK

Under the leadership of the new chairman Mr. H. M. Hobart the Northern New York Section has made rapid headway in starting its activities for the coming season. It has printed a program for the meetings which is reproduced below:

Meetings. Regular monthly meetings of the Northern New York Section are held on the second Friday evening of each month from September to May inclusive. Sometimes due to unavoidable circumstances the meeting date is liable to be changed and additional meetings are scheduled when conditions warrant.

The time and place of each meeting is announced a week or ten days before the time set, by printed cards sent out by the Secretary and also by newspaper notices. These cards indicate the name of the speaker and his topic for the evening.

These meetings are for the members and their friends and those interested in the art of welding in any of its branches. All interested persons are invited to attend these meetings and to participate in the discussions. All meetings are free.

For information as to the publication of papers and references to data on technical points of welding or questions with regard to addresses and standing of members of the Society, write to

W. L. Warner, Secretary,
Room 541, Bldg. 2,
General Electric Company

Tentative Schedule—1923-4

September 14th—Mr. Addison G. Bissell, General Engineering Department, Westinghouse Elec. and Manufacturing Co. Subject, "The Development and Application of Electric Arc Welding in a Navy Yard."

September 28th—Prof. Elihu Thomson, Director, Thomson Research Laboratory, General Electric Company. Subject, "The Early Days of Electric Welding."

October 12th—Prof. Alfred S. Kinsey, Advisory Service Engineer, Air Reduction Sales Company. Subject, "The Uses of Oxygen and Acetylene in Engineering Practice."

November 8th—Mr. G. O. Carter, Consulting Engineer, Linde Air Products Company. Subject, "Some Management Problems on Large Welding Jobs."

December 14th—Open.

January 8th—Mr. W. M. Brady of the General Electric Co. and Mr. H. P. Pennington of the Transportation Engineering Corp. Subject, "The Application of Electric Arc Welding to Railway Transportation.

February 8th—Mr. E. M. T. Ryder, Way Engineer, Third Avenue Railway System, New York City. Subject, "Welding of Rail Joints."

March 7th—Dr. C. P. Steinmetz and Mr. J. L. R. Hayden, Consulting Engineering Department, General Electric Company. Subject, "The Electric Arc and Its Characteristics."

April 8th—Mr. E. Vom Steeg, Jr., New York Office General Electric Co. Subject, "Modern Arc Welding Apparatus."

May 9th—Mr. W. Remington, Chief Engineer, Thomson Electric Welding Company. Subject, "Some Applications of Resistance Welding in Modern Industry."

September Meeting—A graphic history of the development of resistance welding was presented in a popular manner Sept. 28th in Edison Club Hall by Professor Elihu Thomson, director of the Thomson Research Laboratory, General Elecrtic Company, Lynn, Mass. The occasion was a joint meet-

ing of the Northern New York Section of the American Welding Society and the Schenectady Branch of the American Society of Mechanical Engineers.

Hermann Lemp, works engineer of the Erie plant of the General Electric Company, presided at the meeting. He briefly recounted his experiences with Professor Thomson, forty years ago when the welding art was in its infancy. He then introduced D. R. Dalzell, representing Walter S. Moody, engineer of the Transformer Department of the General Electric Company at Pittsfield, Mass. Mr. Dalzell's subject was "The Influence of Early Work on Resistance Welding on Contemporary Electrical Development." After outlining some of the handicaps which existed in the early days under which the pioneers in welding had to work, he told of the work which Professor Thomson did in developing this art.

Following Mr. Dalzell's talk and a short preface by Mr. Lemp, Professor Thomson was introduced. His address consisted of popular recital of the details attending the development of this great commercial art, first conceived in 1877 by Professor Thomson. His discovery of the idea, was accidental and occasioned during the last lecture in a course of five on electricity at the Franklin Institute at Philadelphia. At that time he noticed that while the coarse wire primary coil had its ends closely placed together with a slight pressure, on the passage of the condenser discharge—which was three Leyden jars, a rather large discharge—which might now be called a "snap weld" was made and the ends of the wires so firmly joined that they had to be cut apart.

The first actual machinery to perform welding operations was built in 1885, when the Thomson Houston Electric Company, under Professor Thomson's direction, started to develop an alternating current system with dynamos and transformers. In 1886 the "Jewsharp" coil was developed, by means of which welds could be made between bars of different metals up to about three-quarters inches in diameter for iron and corresponding sizes, according to the heat required and the conductivity of the metal, for other materials than iron.

Before the meeting in Edison Club Hall, a dinner was given Professor Thomson in the Mohawk Club, at which a number of prominent officials of the General Electric Company were present, including Hermann Lemp, F. C. Pratt, J. R. Lovejoy, G. E. Emmons, J. S. Conover, A. L. Rohrer, C. E. Eveleth, William Dalton, F. H. Clough, A. H. Moore, R. C. Muir, W. B. Potter, W. L. R. Emmet, Dr. Irving Langmuir, R. O. Ackerman, J. A. McManus and H. M. Hobart. During the dinner, Professor Thomson absented himself for a short time during which he broadcast a popular condensation of his talk over WGY, the radio station at the General Electric Company. Those at the dinner had the opportunity of hearing his remarks through a loud speaker which was installed in the room.

Slides were introduced at the meeting in Edison Club Hall following Professor Thomson's talk, showing both the early methods and appliances used in welding and the later ones. A general discussion of the subject was held. The hall was crowded to capacity.

BOSTON

An Executive Committee meeting of the Boston Section was held Tuesday evening, September 25th. Plans for increasing membership of the Section were discussed and a program for the meetings of the Section during the coming year was tentatively arranged. This program calls for several demonstration meetings and also some illustrated lectures on various phases of welding.

CHICAGO

The first fall meeting of the Section will be held on Friday, October 5th in the rooms of the Western Society of Engineers, Monadnock Building, Chicago, Ill.

CLEVELAND

A director's meeting of the Cleveland Section was held at the Hotel Winton, Thursday evening, September 20th. A program of activities for the section for the coming year was prepared. Some of the subjects selected are: Cutting by Oxy-Acetylene and Carbon Arc, Pressure Vessel Welding, Pipe Welding, Welding Procedure in Railroad Shops, Welding of Cast Iron, Welding of Non-Ferrous Metals and Safety for Operators.

It is planned to have some of these meetings joint affairs with other engineering societies located in Cleve-

land. It is hoped that in this way membership will be increased and at the same time welding will be brought to the attention of other engineers.

PHILADELPHIA

The first meeting of the Section was held on Monday, September 17th at which time the motion picture, "Steel in the Making" was presented. At the close of this meeting it was decided to again show this picture at the October meeting at which time Mr. Oeschle, the Chairman, will read a short paper on "Steel." The next meeting will be held on November 10th.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the Bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

POSITIONS VACANT

V-12.—Need Superintendent or Foreman of Electric Welding. Can always use some first class electric welders. Location Pennsylvania.

V-13.—Have an opening for a welder. Work Steady. Man expected at times to make guards and repair machinery. Must know how to weld by both gas and electric methods.

SERVICES AVAILABLE

A-19.—Want position in welding repair work. Have had about one year's experience in electric welding of tanks. Will go anywhere.

EMBLEM

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office.

Price, Gold-filled, 75c.; 14-K. Gold, $5.00

INDUSTRIAL APPLICATIONS OF WELDING AND CUTTING AND THEIR POSSIBILITES *

Introduction

Five years ago the increased cost and the great difficulty of obtaining equipment renewals, combined with the shortage of labor, forced executives and engineers to give careful study to the question of repairs. There was in consequence a considerable extension in the adoption by the engineering industries of the electric arc, oxy-acetylene and thermit welding processes not only in the repairs of broken machine parts, but also in the filling in of faulty castings formerly rejected.

The remarkable success obtained by these welding processes led engineers and designers to extend their application to their simpler construction problems. Each new experience and success brought about increased confidence and further extension. As a result the application of welding is almost universal in extent.

Although the extension of the use of welding has been remarkably rapid, it was, up to a few years ago, retarded by the shortage of reliable up-to-date information from disinterested sources and lack of research and means whereby investigation could be carried out. This is no longer the case as the American Welding Society through its meetings and the Journal, meets the need for reliable information and its research department (The American Bureau of Welding), provides the means of conducting necessary investigations on a co-operative basis.

Possibilities of Welding As a Fabricating Process

The manufacturing process of building a large structure by riveting consists of the following:

1. Design.
2. Making drawings.
3. Making templets.
4. Marking steel.
5. Punching or drilling holes.
6. Assembly.
7. Riveting.
8. Painting in shop.
9. Erection.
10. Painting in the field.

At the present time there would be very little saving in the time taken to design a welded structure as compared with a riveted one. This is due largely to the fact that in most cases both would

* Prepared by the Meetings and Papers Committee, A. W. S, to be presented at the Industrial Applications Session Fall Meeting, A. W. S., October 1923.

involve the same kind of stress determinations. However, a shop drawing of a riveted structure requires a great deal of time and entails a large expense for practically every dimension is indicated on the drawing, every rivet is carefully located and the size, width and length of every structural shape is given. The amount of work involved is readily estimated when one considers that in a very simple small plate girder railroad bridge there are about 6,000 rivets. A very small fraction of this time would be needed in preparing working drawings for a welded structure.

After the drawings are finished for riveted work, they are sent to the templet shop where full size templets made of wood or heavy leather board are prepared for each and every piece in such a way that all holes to be finally placed in the steel are indicated in position and size on the templets. These templets are then sent into a shop where they are clamped to the steel and each steel piece is marked to conform to its duplicate both as to size, shape and location of all holes. These pieces of marked steel are then passed through shearing machines, shearing them to shape and through punches to punch holes. The numerous pieces which make up the girder or other members and which have been cut to shape and punched are now assembled and temporarily bolted together with a few bolts—all the parts and pieces of steel which are in contact having been given a coat of paint.

In contrast to the work involved in riveted structures outlined in the above paragraph, all of it is omitted in the welded structure.

The assembled members, if they are to be riveted, are taken to the riveting machines either fixed in position, in which case the piece to be riveted must be moved in order to bring the rivet in the proper position in the riveting machine or the riveter is portable for use on heavy work and is so arranged that it can be moved about as the rivets are driven. In driving rivets it is frequently found that because of inaccuracy of workmanship holes do not come exactly opposite but by driving a drift pin the holes are more nearly brought in line before a rivet is driven. Most of the holes in structural steel work are punched and after being assembled are then reamed to get a smoother and larger hole. On heavier materials or parts where the best results are desired, holes are drilled.

Again, in contrast to the above, in the welded structure the parts to be fastened are held together temporarily by small "tack welds," requiring only a minute or two to make or by suitable clamps. There are no holes to align and welding progresses steadily from one end of the seam to the other.

As a general proposition, the riveted or bolted joint has a tensile strength considerably less than the original piece whereas the welded joint may be made as strong as the original section. Moreover, the welded joint is oil and watertight up to its break-

ing point, while the riveted and caulked joints leak badly at as low as 25% of the ultimate strength.

Everything considered, it is conservative to state that in most cases the fabrication of steel by welding can be done with a saving of 25% over that of the riveting and with a better quality of product. A saving may not be effected in the first structure, but will undoubtedly be brought about as familiarity with the process and its use is attained by designers, draftsmen and workmen. It should be also pointed out that in some instances the superiority of the finished product would justify the use of welding even though it cost several times that of riveting. A striking example of this is in the construction of oil storage tanks for lighter oils. The present riveted structure is not sufficiently tight for holding these oils and the savings which would be effected by prevention of the loss of oil from leakage and evaporation would in two years pay entirely the cost of the welded tank. Welding has also recently been used in the fabrication of some large gas holders with a saving in cost and improvement in quality of product.

Possibilities of Welding in the Repair Field

There was a time when the wearing of a fraction of a cubic inch of metal from one of the wearing surfaces of a piece made it necessary to scrap the part with a consequent loss of material and labor investment. It was only after the introduction of the fusion welding processes that it became possible to stop this economic waste. By spending a few dollars for welding in some instances it is sometimes possible to save parts involving many hundreds of dollars, not only by reclaiming the worn parts, but in savings due to the much less time required for welding than for replacing them by new ones.

The repair of broken members of machines has been another important engineering achievement made possible by the electric, gas and thermit processes. Here, again, there are instances every day where the returns on the money spent in welding are as high as 1,000% as compared with replacing these broken parts by new ones.

Of recent years there has been a strong tendency towards substituting castings made of steel for those made of cast iron. The reasons for this are the less weight of steel castings for the same strength and their much less brittleness and consequent freedom from breaking under shock. But, steel castings are more liable to defects such as blowholes than are cast iron ones, and as their cost is higher any process that could reclaim steel castings is of great benefit to the manufacturer. Such welding processes are used very largely for this proposition and have resulted in material saving and doubtless in the extension of the use of steel castings

in place of cast iron because of the reduction in cost affected by welding processes.

Very often mistakes are made in machining and were it not for welding, these valuable castings would be rendered useless. As it is, the only loss is the time and money necessary to deposit new metal by one of the welding processes. Here, again, the returns on the welding investment may be as high as several thousand percent.

ARC WELDING

In illustrating the possibilities of arc welding, one of the engineers employed by an arc welding company tells the following story:

"The other day I was in conference with the principal owner of the company in which I am employed. Just outside the window they were shooting up one of these modern steel office buildings

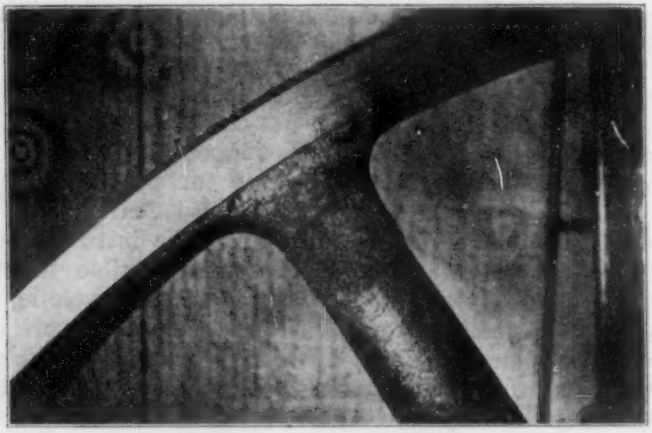


Fig. 1—Broken Fly Wheel Repaired by Electric Arc Welding

and fifty riveting machines were clattering at once. After a vain attempt to talk louder than the riveting machines, he jumped up and shut the window with a most efficient slam. 'Confound that infernal noise!' said he. 'Don't you think that something could be done to stop it?'

" 'That,' said I devoutly, 'shall be my life's work! Let me explain.' And I did explain, I think, very thoroughly, how it was possible to make joints of 100 percent strength by the arc welding process; how it was thereby possible to reduce the quantity and size of structural members; how the working unit could be reduced to about half; how the intricate operations of laying out, punching and fitting could be avoided, and finally, how din and bustle of a boiler shop could be greatly reduced. Nor was I at all finished with the subject when I had said all this, but I had

to stop for breath, and so gave the opportunity for a come-back. 'Good stuff,' said he, 'but it seems to me, your job is too easy. You ought to be selling your apparatus like hotcakes!' "

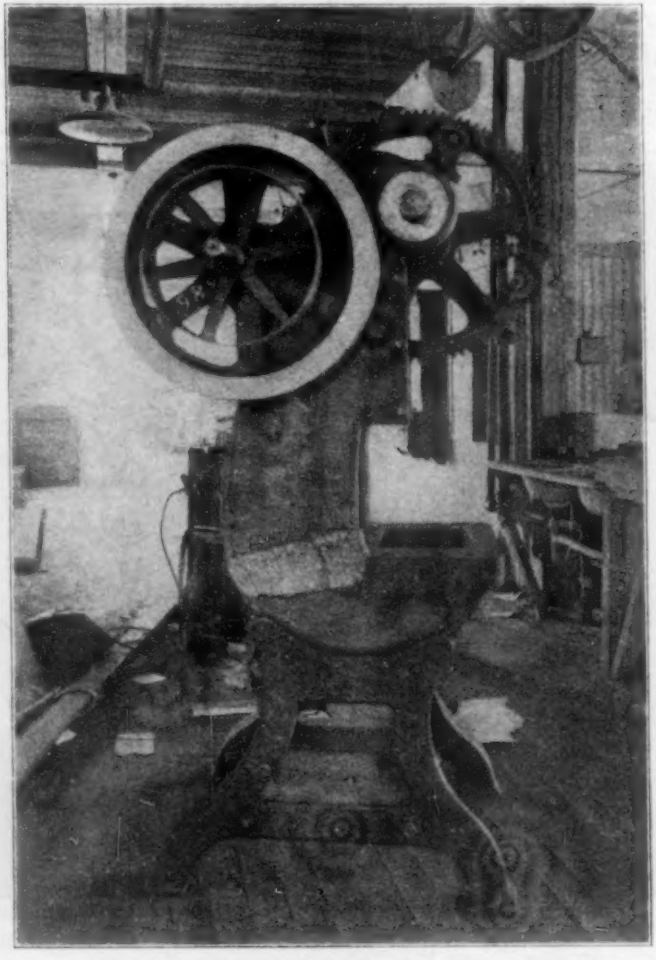


Fig. 2—Punch Press Restored to Service by Electric Arc Welding.

True enough, but, unfortunately, among those who might use it to great advantage, there is a lack of knowledge of the subject. There is the bugbear of precedent. Architects and civil engineers are unwilling to take what they consider to be a risk in specifying arc welding, and, in spite of convincing demonstrations, will largely refuse to have anything to do with it. Following these cautious ones, come the formulators of the building codes; neither of the two seems to want to be the first to take the plunge.

Nevertheless, the advance of arc welding, although at present slower than it should be, is inevitable, because it is thoroughly

practical and usable, and because it stands for progress in every field. Steel companies that have sufficient forward vision are already preparing for the time when arc welding will supplant the rivet, and they are gaining experience in its use upon the smaller welded sections, or in minor operations which do not require approval. These firms are wisely preparing themselves against the time when the avalanche starts and the reward for such preparedness wil be a vast saving in cold, hard cash.

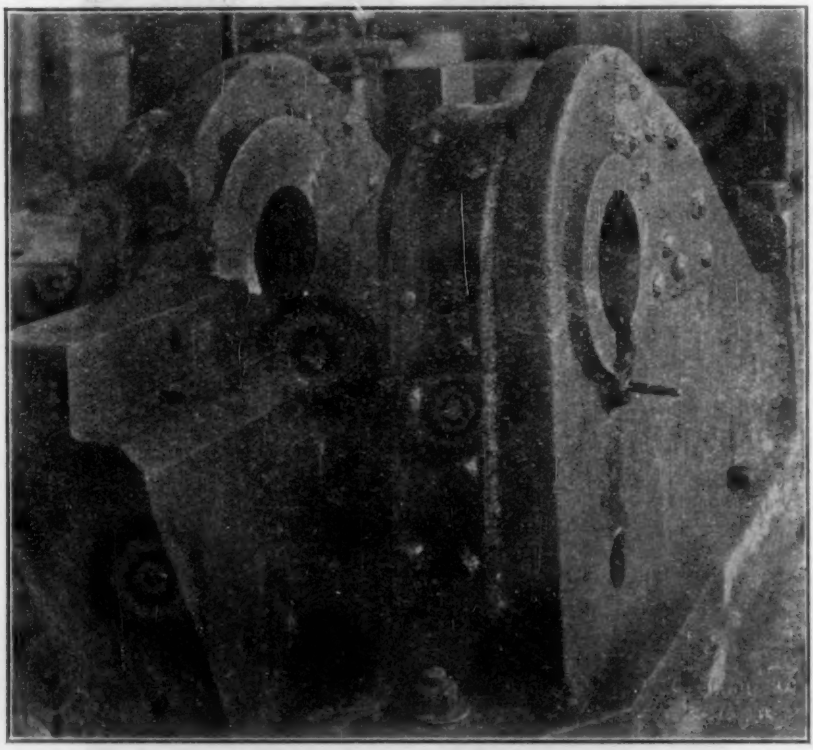


Fig. 3—Alligator Shear Saved by Electric Arc Welding.

I wonder how many people actually do realize the remarkably rapid progress already made by the arc welding industry. In the production of low pressure tanks, for instance, the entire country has turned from riveting to welding. This radical change has taken but two years, and has come about as the result of a perfectly natural evolution.

A multitude of minor structural firms, and many large ones, have to their great advantage adopted this new tool, as in the automotive industry, the iron and steel works of the country, the engineering and contracting companies, the steam and plumbing industry, including the laying of steam, water and other pipe lines,

as well as the two industries that did most to develop the process —the shipbuilding and railway companies. In connection with the laying of piping and similar operations, an interesting point has developed. In Canada, and parts of the United States more or less remote from the steel centers, it has been found that great savings are effected for some kinds of pipe by shipping the steel "flat," that is, unformed. After it has arrived, it is then rolled and welded into pipe. The enormous saving possible by this method is apparent when it is seen that bulk is infinitely more expensive to transport than compact weight; the bulk is, therefore, not shipped at all, but is created after arrival. The method is peculiarly applicable to large diameter thin pipe.

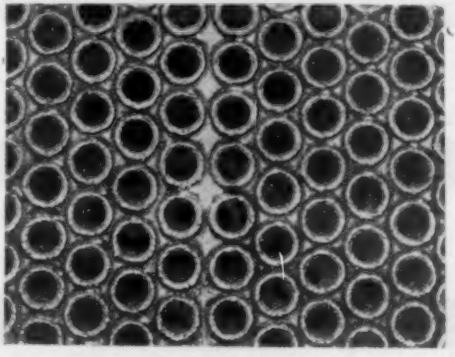


Fig. 4—View of a Flue Sheet in which all the flues have been electrically welded. Note the smooth and uniform welds. Previous to welding these flues would leak in three months. Welding increases life to three years.

To the railway companies belongs the credit for sponsoring arc welding in its infancy. Some of these companies have made use of the process for more than fifteen years, chiefly as a repair utility, and a detailed list of the specific uses to which it has been put would occupy a volume of its own. As experience shows conclusively that joints stand up without failure, more and more of the fireboxes on new locomotives are being welded. It is the standard practice on many railroads to weld all the flues in the firebox end when the locomotive is built and when they are reset. While these flues would, under constant service, ordinarily begin to leak in about three months, they have withstood leakage for three years when welded.

When the war came, and brought with it the necessity of great increase in speed and efficiency in shipbuilding, electric arc welding was provided with a chance to demonstrate its worth. That it came up to all expectations is now but a matter of record. The shipbuilding industry took over the process as developed by the railroads, and, under the pressing necessity of the nation's need, developed it to a high degree of perfection. This was especially

the case in the working out of the fabricated ship idea. After all, the building of a ship is like the building of a skyscraper clothed in sheet steel instead of in brick or stone, and the skeletons of each are very similar. Then why not the all-welded ship? After the war-time success of the arc process, Lloyds and the American Bureau fell into line and issued a list of suggestions and approved welded parts, and a few more months of war necessity would probably have seen the completely arc welded ship in actuality. However, this result will be created sooner or later by the sheer merits of arc welding.

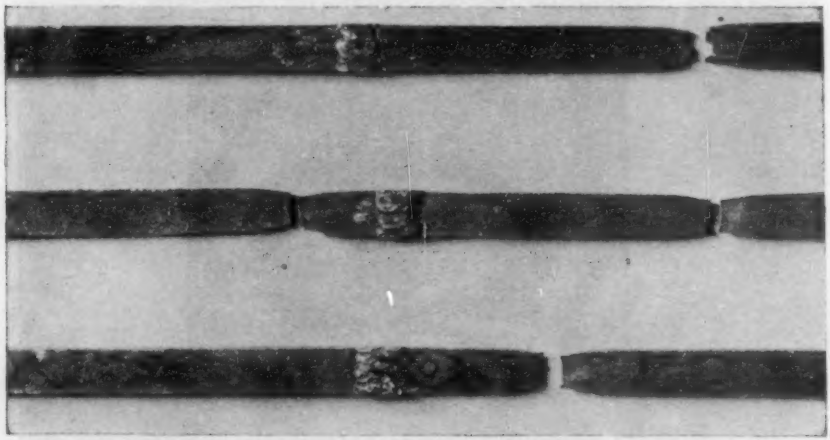


Fig. 5—Arc welded specimens broken by tensile tests. Note that the break is in the steel outside of the weld. A double Vee weld in low carbon steel plate can always be made stronger than the steel itself.

An event which brought arc welding into prominence occurred at the very inception of the war, when the cast iron parts of the engines of some of the interned ships were destroyed. No doubt the instructions to do this damage were based upon the belief that the large cast iron parts, once cracked, could not be repaired, but Yankee ingenuity had already developed the studding process, which made possible the complete and satisfactory repair of the broken parts.

As far as production is concerned, I firmly believe that there exists no metal trade or business that will not ultimately come to use arc welding methods, while, for repair work, there is a use for this process everywhere.

So, too, in the beginning, the steel industry rather shied at the brilliant light of the arc, and maintained that it could recast broken parts more cheaply than to weld them. Recast them—yes, but now the recasting is done locally by the aid of the arc. Why recast an entire piece, when you only need to recast the metal around the break or defect. It was obvious logic, and as soon as they

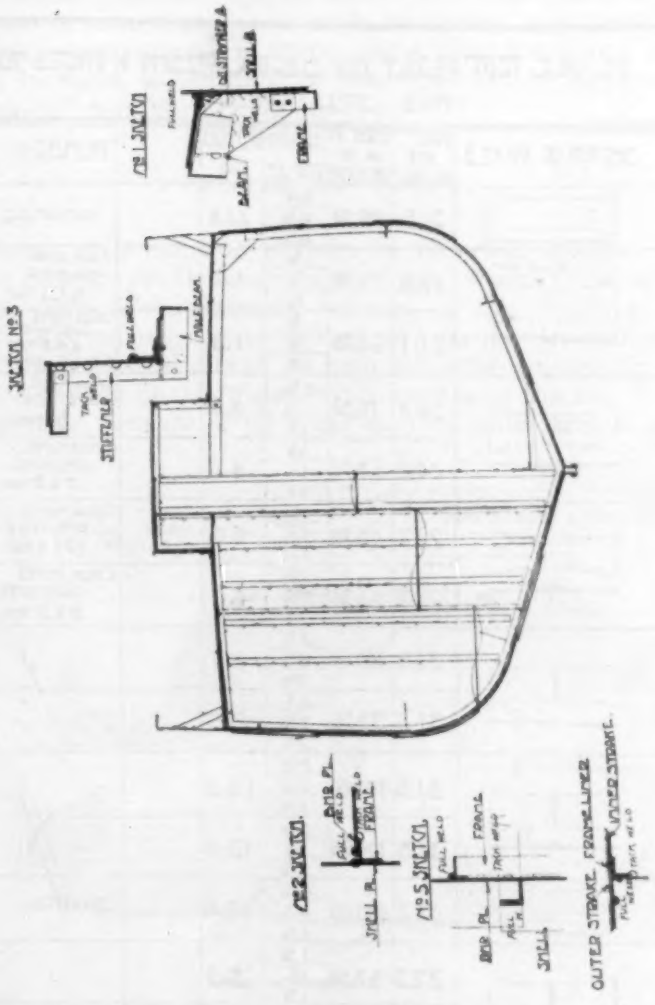


Fig. 6—Midship Section of the "Dairyo Maru," a Japanese steam trawler, 95 ft. by 2b ft. beam and by 12 ft. 6 in. in depth converted by electric welding into an oil lighter, capable of carrying about 300 tons deadweight. The advantages of welding have geen quickly recognized by the Japanese. The American Bureau of Welding (Research Department of the American Welding Society) has prepared a critical review of the existing information on the application of arc welding to ship construction. It includes proposed designs of welded ships, comparison of riveting versus welding, cost data, test data, test results, description of the eight welded vessels already in existence, a list of the parts that may be welded as approved by Lloyd's and the American Bureau of Shipping and other information of value to the draftsman and ship designer.

saw that it could be done, they hastened to acquire not one, but many machines, for the purpose.

Such is the march of progress that there is not a steel mill now in which arc welding is not well-known, and the most difficult jobs have been easily and satisfactorily accomplished by its aid. Some of these may be interesting; they include the padding-up

TENSILE TEST RESULT FOR ELECTRIC WELDING & RIVETED JOINT
MILD STEEL PLATE

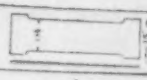
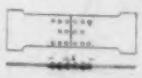
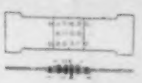
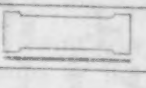
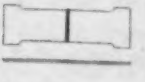
SKETCH OF PIECES	TONS PER SQ. INS.	TONS IN % OF ORIGINAL	ELONGATION FOR 2T	%		REMARK
	31.5	100.00	6 4/16" 6 5/16" 6 6/16"	23.8		ORIGINAL
	22.6	71.74	5/8" 5/8" 5/8"	1.4		CAULKING OPENING 87.5 TON
	21.1	66.98	5/8" 1/2" 1/2"	1.9		CAULKING OPENING 64.8 TON SLACK 1/16 - 81 TON
	24.2	76.82	1 5/16" 1 1/16" 1 1/2"	5.3		CAULKING OPENING 81 TON
	20.7	65.71	1 1/8" 1 1/4" 1 1/8"	4.6		CAULKING OPENING 71.3 TON
	21.7	68.88	1 1/16" 1 1/16" 1 1/16"	6.3		CAULKING OPENING 121.1 TON
	21.7	68.88	1 1/16" 1 1/16" 1 1/16"	6.3		CAULKING OPENING 97.2 TON
	31.5	100.00	2 1/16" 2 1/16" 2 1/8"	8.1		
	31.3	99.36	2 1/8" 2 1/16" 2 1/16"	9.5		
	31.5	100.00	2 3/16" 2 1/16" 2 3/16"	10.0		
	31.8	100.95	3 3/16" 3 1/2" 3 1/16"	13.0		
	31.2	100.00	4 3/16" 4 1/16" 4 3/16"	16.4		ORIGINAL
	27.3	87.50	1 3/16" 1 1/16" 1 3/16"	5.3		
	28.4	91.02	1 1/2" 1 1/2" 1 1/2"	5.6		

Fig. 7—Table showing tensile and elongation test results of arc welded and riveted joints on mild steel made by the Mitsubishi Shipbuilding Co. of Japan to determine the adequacy of the welded joints.

of worn wobblers which are hardened and smoothed at the same time by the use of the carbon arc; water-cooled fire-door repairs; repairs of bearing breakages and rolling stock; repairs from wear

and accident, including special locomotive jobs; repair of miscellaneous breakage and wear such as broken gear teeth, worn key-ways, worn armature shafts, misdrilled holes and lack of bosses; in short, a multitude of jobs that can be handled by a "putting-on" tool, the first of its kind.

Electric Arc Cutting

Although it is common practice in the steel industry to use gas for cutting, yet there are many places where the electric arc may be used advantageously because of the resulting saving in cost. Arc cutting may be defined as a resultant combination of the melting of metal due to its high temperature, and the oxidation of a portion of this metal by the oxygen of the air. This oxidized portion, because of its lower melting point, acts as a lubri-

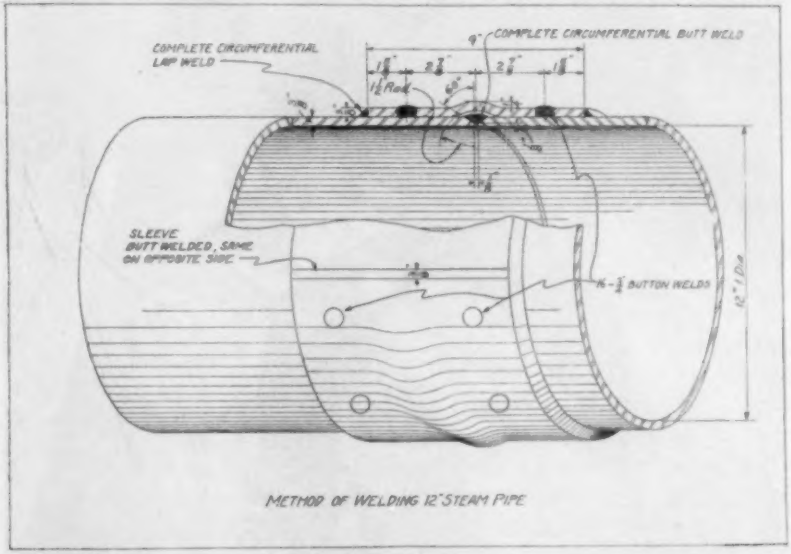

COMPLETE CIRCUMFERENTIAL LAP WELD
COMPLETE CIRCUMFERENTIAL BUTT WELD
SLEEVE BUTT WELDED, SAME ON OPPOSITE SIDE
16-¾ BUTTON WELDS
METHOD OF WELDING 12" STEAM PIPE

Fig. 6—Design of joints in a 2200 ft. high pressure underground steam line constructed by Philadelpphia Electric Co. In order to make this line absolutely steam tight each joint is reinforced by an external sleeve welded securely to the two ends of the pipe. The butt weld is made by the oxy-acetylene process and the two lap sleeve welds are made by the electric welding process. This line has been in continuous service for several years under a pressure of 130 lbs. per square inch.

cant and tends to slide off the greater masses melted by the heat of the arc.

In arc cutting, gravity must be utilized in that the operation must be performed from the vertical or underside. Many attempts have been made to use oxygen or air under pressure with arc cut-

ting, but it has so far been found impractical to do this. This is due largely to the non-synchronous disposition of the arc with regard to the air or oxygen stream, that is, these two could not remain close enough together to give the desired effect. However,

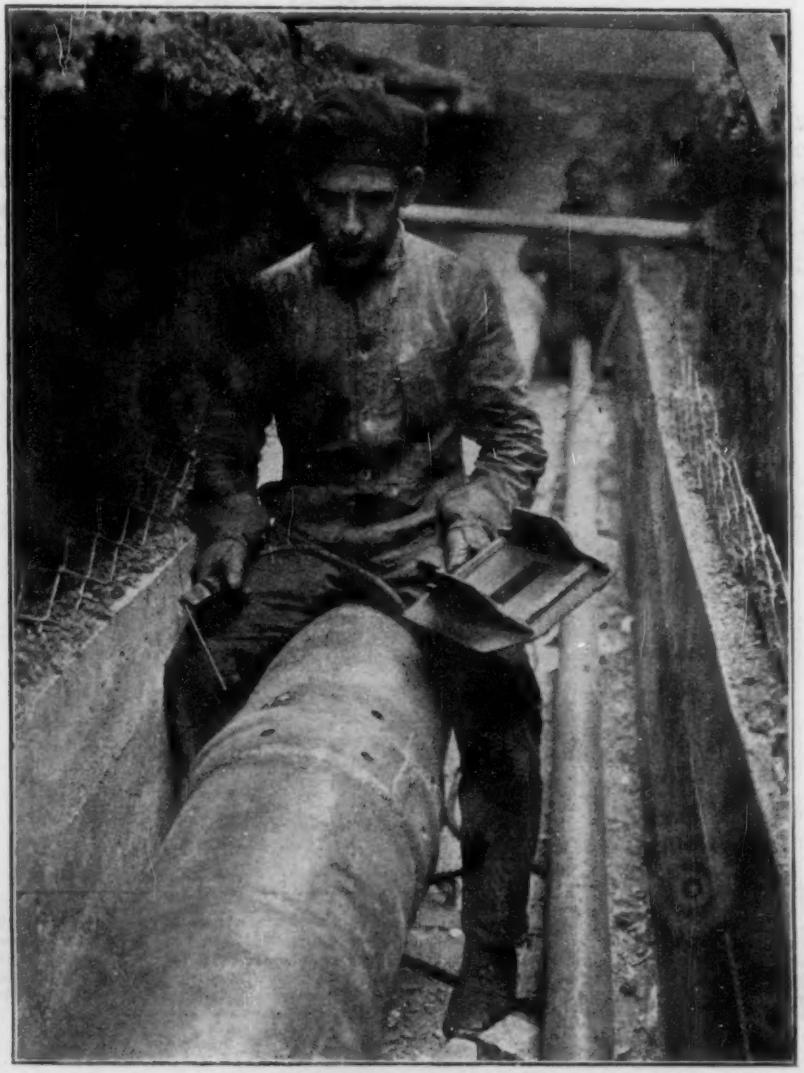


Fig. 9—View of joint in welded high pressure steam line referred to in Fig. 8.

the intermittent use of compressd air or oxygen with the arc has been made successful by releasing a stream or air after the arc has made the puddle molten, and by blowing it away upon the

oxide lubrication. This method is especially useful in rivet cutting on a top or horizontal surface.

A handle is manufactured which combines this arc and air stream operation in one small unit. It is easily carried and operated by one hand, thus giving the other control over the arc and air streams. This arc will cut any metal: viz: brass, copper, zinc, lead, cast iron, malleable iron, high carbon or alloy steels, etc. Considering the supply of heat energy necessary, the electric arc process is also cheaper than the gas. Yet, for heavy work, the

Fig. 10—View of one of the 40 tanks tested to destruction by the Bureau of Standards for the American Bureau of Welding to furnish the Boiler Code Committee of the A. S. M. E. with reliable data to enable them to draw up a satisfactory code governing the use of welding in the construction of unfired pressure vessels and also to furnish data for suitable tests of the finished tanks.

The particular tank shown above was gas welded and made of ¾" steel 16" in diameter and broke outside of the weld at 1740 lbs. per square inch hydrostatic pressure.

use of the gas method is the best practice because of the speed possible. Moreover, for heavy and careful work, gas can equal machining methods, for which the electric arc cannot be considered. For rough work, however, such as cutting up scrap into charging sizes, or for work requiring subsequent machining, the electric method is the cheaper, providing the thickness of the piece is not too great. For cutting non-ferrous metals, the arc is thus far superior. The arc will efficiently cut the scrap sections of cars, boilers or tanks into charging sizes, and will rapidly cut through sills, channels, or other stiffening members at a rate proportionate to their thickness, but always at the same low cost of power.

For straight arc cutting, the thickness that can be economically "eaten through" by the arc is under six inches, and lies between two inches and six, depending upon the price of power and other considerations. For heavier sections, the speed of gas cutting is greater than that of arc cutting, and is the cheaper because of smaller labor costs. There is, however, a method of nicking and

breaking in which the electric arc is more efficient than gas for any size material. In any average scrap pile, the work is more economically done by the electric arc; the heavier sections may be nicked and broken, or cut through with gas.

The arc may also be used to cut cobbles, hot or cold; fringe or overflow of ingot moulds, and miscellaneous cutting and marking of scrap ends due to rolling defects and the like. One of the striking examples of economy is found in rivet cutting by the arc. One man with the arc (power cost very small) will cut from one hundred to two hundred rivets an hour.

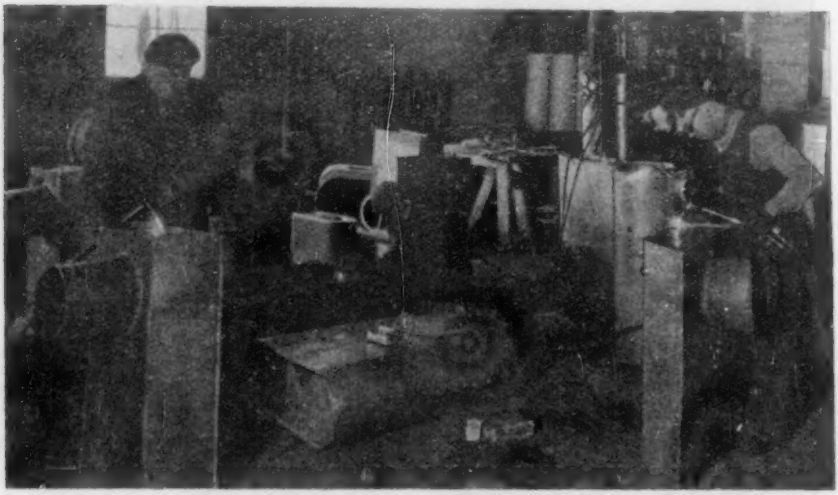


Fig. 11—Section of Central Welding Shop in the plant of a Western furnace manufacturer. Parts being welded are radiators for all oxy-acetelene welded hot air furnaces which are permanently leakproof and gas tight. Welded construction has overcome the objectionable feature of riveted and cast iron sectional furnaces.

OXY-ACETYLENE WELDING

That the oxy-acetylene welding process will play an important role in our industries is indicated by the fact that institutions of higher learning are now offering courses of instruction in the fundamentals of welding. In some of the larger cities even the high schools are doing their share, and in every case where any of the mechanical arts are taught, instruction in oxy-acetylene welding is now being given. Manufacturers in large centers are becoming enthusiastic and are organizing and conducting welding schools at their own expense.

Our leading economists inform us that the most successful manufacturing enterprises from now on will be the ones operating along the most efficient lines. A wide-awake engineer will therefore give

due consideration to the process of welding. Manufacturers of steel products such as the various types of barrels, tanks and pressure vessels should give considerable attention to design in order to produce the strongest and most efficient product at a low cost.

There are many reasons why manufacturers should use a welding torch in preference to rivets, one of the most important being the fact that fittings of almost any nature can be attached in any

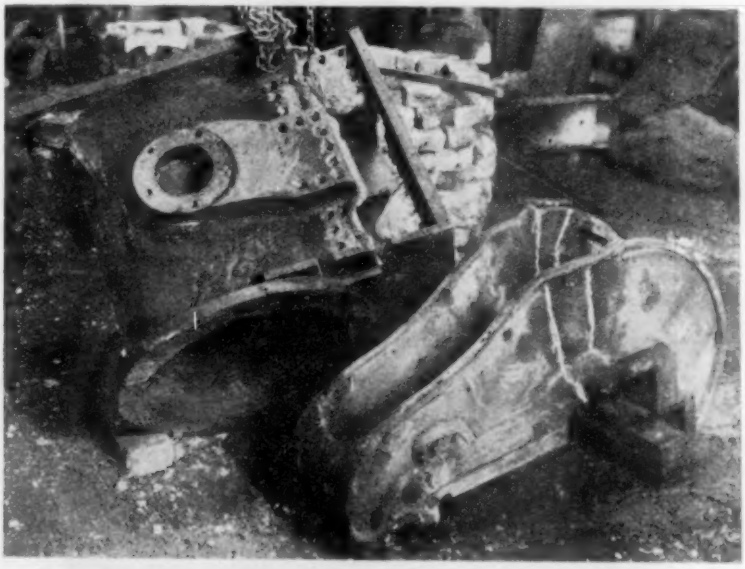


Fig. 12—Heavy Welding Casting at the left in the photograph is a steam cylinder from a tug boat which was oxy-acetylene welded and when tested proved absolutely tight. It has been in constant service since. The other casting is a punch press frame which broke into halves and was reclaimed. The welded section, before finishing, is shown between the chalk lines.

position with ease, allowing a much greater latitude in design and structure. Steel castings may be fused to cold rolled shafts or other stocks thereby opening up another lane. Automobile or tractor frames and structural iron of all kinds need not be limited as to design for various parts can be fused together at any angle desired. Fuel tanks, fenders, pressed steel wheels, rims and pulleys are some of the possible applications of oxy-acetylene welding.

In repair work oxy-acetylene welding has made possible a saving of many parts which otherwise would have to be thrown away, such as broken automobile cylinder castings, crank cases and parts of all kinds of machinery. Some special applications are found in the reclaiming of cracked castings in foundries, the filling of blowholes in castings, the adding of metal to worn surfaces to secure

the original size, the welding of pipe without removal, the filling of drill holes that have been incorrectly located and the sealing of riveted seams thereby securing absolutely tight joints.

In the field of oxy-acetylene welding a further extension of the process to maintenance and repair work has been most impressive and great many plants have built up central welding shops which are quite to be compared to machine shops as run by large plants for maintenance work.

Fig. 13—Pipe Welding. The joining of sections of pipe for pipe lines to carry water, air, gas, steam or other materials under pressure has become a very important use of the oxy-acetylene blowpipe.

A study of maintenance and repair welding has brought out very strongly htat there has been a lack of knowledge due the correct methods of handling cast iron welding. When plants have been instructed to properly preheat work and follow the welding operating with annealing the results have been practically 100%. Similarly in other kinds of work where failures have occurred they are traced to lack of knowledge as to proper methods to be employed or willful negligence.

A notable example of recent applications is the welding of oil pipe lines. Very recently a 140-mile 8″ pipe line was welded by the Prairie Pipe Line Company and has been giving excellent service for practically a year. There are three intermediate pumping stations and the line has been welded into a continuous tube from one station to the other on this system, there being no coupling joints whatever. This 8″ line carries 750 lbs. oil pressure as its maximum and has had a thorough test under working

conditions due to the usual washouts during the heavy rains in northwestern Texas.

An investigation during the past year indicates that some fine steam installations have been made by welding by the American Woolen Company, Globe-Wernicke Company, The American Can Company, Warren Iron & Steel Co., and the J. P. Coates Company.

Fig. 14—Welding dredge pontoons. The welded seams on these pontoons which were used in dredge work on Lake Michigan proved strong and tight under the most severe usage.

During the past year two 1,000-barrel oil storage tanks were gas welded. These tanks were tested by putting 2″ of kerosene on each bottom after the first rings were welded in place and they proved to be absolutely leaktight. After the joints were completed they were filled with water and all joints were hammered with heavy wooden mallets. If more adequate or more severe tests could be thought of by those who were interested in the construction of these tanks they would have been applied.

These few examples of recent application indicate that the oxy-acetylene welding process has not been applied to the extent to which it could be used with economy and advantage.

OXY-ACETYLENE CUTTING

Cutting metals with the oxygen torch using acetylene and other fuel gases for preheating has been developed during the past decade to breadth and scope hardly dreamed of by the original promoters.

Oxy-Acetylene cutting at first was restricted to wrought iron and steel, and the principal applications are still the cutting of steel. Within the past four years gray cast iron cutting has been made possible, and while cast iron cutting is frequently regarded as an emergency method of separating a casting, it nevertheless is a method of great value in many cases, some of which are not

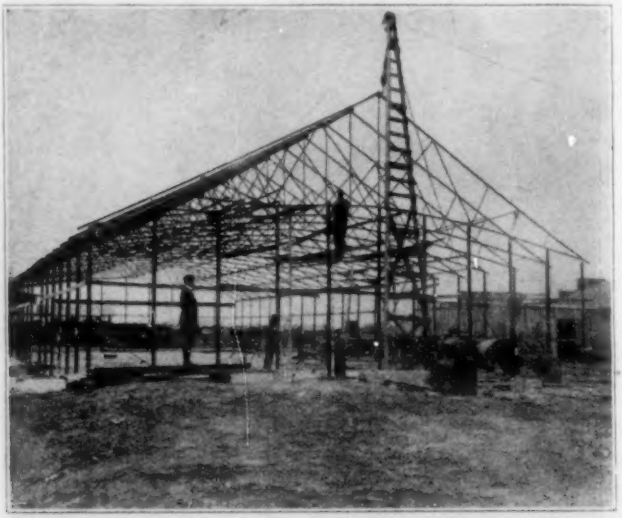


Fig. 15—Building frame structure of scrap pipe by welding. This money-saving application of welding has been used in many sections of the country for many types of small buildings.

in the emergency class. For instance, bolsters of blanking dies must necessarily be cast in blank and the opening cut to match the outline of the steel die. Makers of large blanking dies have found that they can advantageously cut the bolsters with the torch, saving considerable expense thereby.

Experiments have shown the possibility of cutting non-ferrous metals, and while it is too early to predict what will be the ultimate success we know there is a sure possibility of using the cutting torch much more broadly than it is generally used today.

Cutting in Railroad Shops

Boiler side sheets, flue sheets, tubes, flues, crown-bolts, stay-bolts and rivets are cut with the torch, the process saving time and labor to an extent hardly dreamed of by those unfamiliar with present locomotive repair practice.

Frames are beveled for welding when cracked or broken. Bolts are cut off and burned out when stripping the locomotive for repairs, and in many other ways the cutting torch is employed as a tool of general utility for removing worn parts that require replacement.

One of the astonishing applications of the cutting process, to the engineer familiar with the older methods of practice in railway shops but not up-to-date on present methods, is the removal of broken stay-bolts and the cutting off of new staybolts that have been screwed in place, thus making them ready for heading over.

An expert cutter can perforate and cut off a broken staybolt one inch in diameter or less in ten to twelve seconds, and keep up

Fig. 16—A welded mixing kettle. This sheet steel mixing kettle was built entirely by welding. Even the heating coils shown on the bottom were fabricated with the welding blowpipe.

the performance for hours. Records are available of staybolt burning at the rate of 300 to 350 per hour. Replacement staybolts are cut to length for heading down somewhat faster. The cutting torch is a valuable auxiliary tool to the welder. With it he bevels parts to be welded. Shallow cracks are quickly opened up with the torch at any angle required for a sound weld.

Steel Foundries

The cutting torch has greatly changed steel foundry practice. One of the former large items of cost in making steel castings was sawing or otherwise cutting off the risers with machines and planing down the riser necks flush with the casting. This means transporting the castings to machine tools and taking them away

again when finished. With the cutting torch the gates and risers are cut off on the foundry floor often while the castings are still hot. Considerable study is being given to the shape of risers in the effort to modify the shape next to the body so as to facilitate cutting.

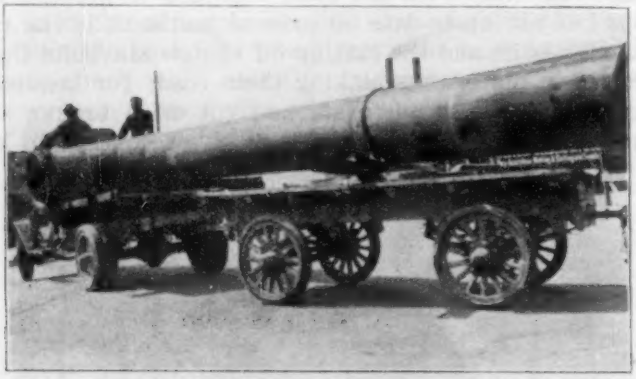


Fig. 17—Welded ventilator duct. A ventilator duct fabricated by welding is an example of the many applications of welding to the fabrication of sheet metal equipment.

Fabricating Structural Steel

We can touch only on some of the remarkable work done in fabricating plate and other forms of steel for bridges, buildings and machinery. The resourceful engineer can direct cutting operations so effectively that certain types of machinery can be 90 percent produced with a cutting torch. Slow and costly ma-

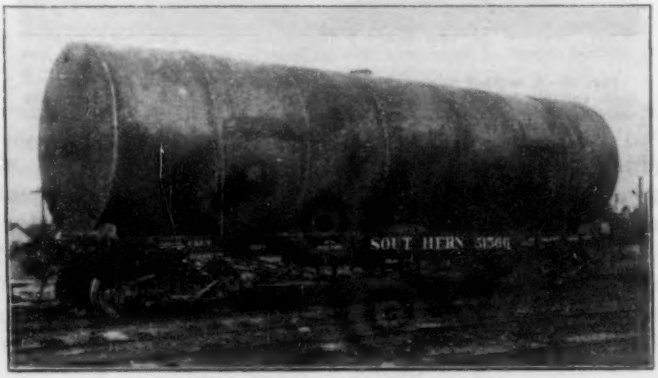


Fig. 18—Welded storage tank. This large storage tank is truly a one piece tank, having been entirely made with welded seams.

chine tool operations are eliminated to say nothing of the transporting of material to and from the machine shop.

Cutting, Auxiliary to Forging

Forge shops are using the cutting torch to advantage as an auxiliary in forging operations, thereby saving time at the hammer and hot, arduous cutting operations. Moreover, the judicious use of the cutting torch has reduced the cost of certain forging operations by simplification. For instance, crankshaft forging is very much simplified and the cost reduced by planning the operation with reference to gas cutting. A multiple-throw crankshaft is made from a flat slab of steel, the openings between the cranks

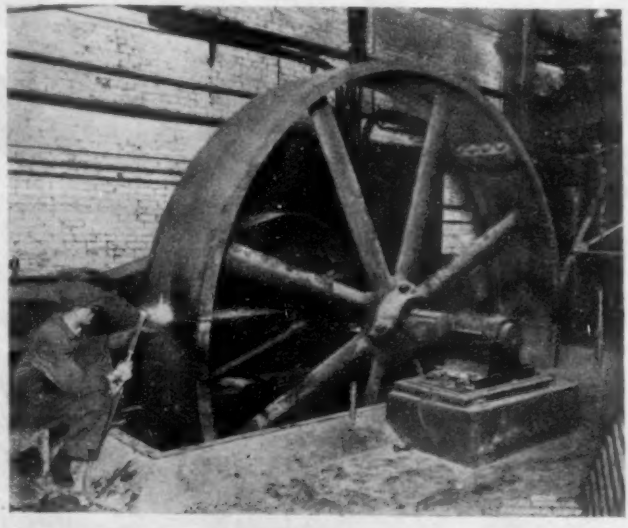


Fig. 19—Cutting cast iron with the oxy-acetylene blowpipe. The ability to sever cast iron sections quickly enables mechanical men to save money and time in construction work, demolition and in the replacement of machinery parts.

being cut out first and the blank cranks twisted to the required angular positions. Then the openings between the crank cheeks are cut. A full description of the operation would be out of place here. Suffice to say the cost of forging operations has been reduced 50 percent in certain cases.

Pipe Cutting

Pipe welding has rapidly gained favor for gas lines, oil lines and water lines for fire protection in large industrial plants. The cutting torch is indispensable to the pipe welder; in fact, the welding torch and the cutting torch have replaced the pipe tongs and pipe cutters. The torch is used for beveling the joints when not beveled at the mill, for cutting pipes at angles, in making up ells, tees, crosses, headers, etc. If an outlet is required at any point it is a quick and simple matter to cut the opening required for the insertion of the nipples to be welded in.

Scrap Cutting

Many hundred thousand cubic feet of oxygen are consumed annually in the scrap yards cutting up old boilers, machinery and

Fig. 20—Clearing away the debris after fire destroyed a large packing plant. A maze of metal including steam and brine pipes, structural steel, cast iron pipes and forms was reduced to handling size with the cutting blowpipes as fast as the wrecking contractor could remove the debris. Weeks would have been required to accomplish the same work by laborious old methods. The portability, scope and comparatively low operating cost of the oxy-acetylene cutting process makes it invaluable for this type of work. Wherever a man can reach the cutting blowpipe can be operated.

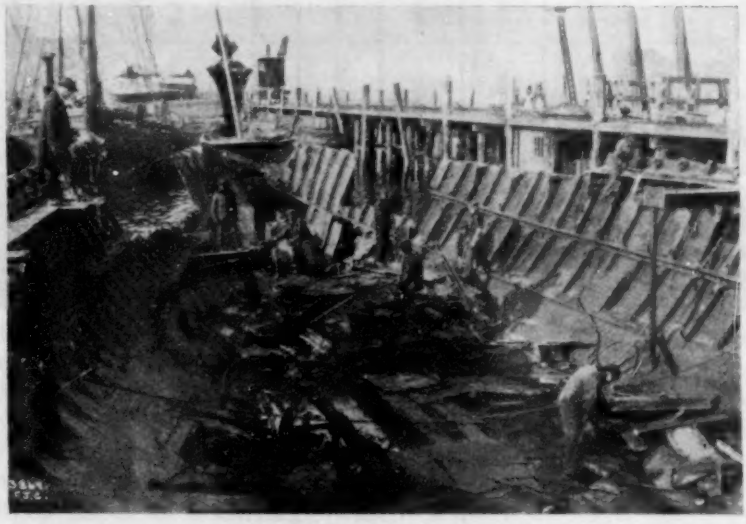
miscellaneous scrap. In some places heavy cast iron scrap is also cut with a torch because local ordinances forbid the use of a drop ball for breaking.

Machine Cutting

The possibility of fixing the cutting torch in a machine having provision for holding the torch at any desired angle and traversing it at a predetermined even speed was recognized early in the de-

velopment of gas cutting. Several machines of the stationary, portable and semi-portable types have been developed successfully. Some of the advantages of machine cutting of interest are as follows:

1. Cuts are perpendicular to the surface or if required at an angle the angle is held uniform. This means that with a given gas pressure adjustment and tip size the gases are presented uniformly to the cut. In hand cutting, especially thick material, the tendency is for the operator to hold the torch at various angles, especially in starting. This wastes gas and reduces efficiency.
2. Cutting speed is uniform and may be adjusted very close to the limit possible with a given tip and pressure adjustment.
3. Cutting of plates, billets, structural shapes and other sections can be standardized and production estimated with close accuracy.
4. Mechanical cutting is smooth and true. In many cases the cuts may be made so smoothly and with such exactness that no further finish is required. Parallel rod and main rod ends are cut in some railway shops to the line and no further finish on the outside is given them.



Fgi. 21—Scrapping a merchant ship with cutting blowpipes at Norfolk, Va. When photograph was taken over 300 tons of metal had been cut to charging box size and loaded on cars.

In fabricating machinery, tools and apparatus with the cutting torch accurate cutting is indispensable. Obviously machine cutting is the process to be relied on if gas torch fabrication is to be highly successful.

Cutting Field Rivet Holes

Not the least important of the many uses for the cutting torch is cutting rivet holes in beams, channels and other structural shapes in the field. Of course, a rivet hole cut with a hand torch must be reamed to remove the irregularities and make possible a tightly fitted rivet.

This review touches only a few of the high spots in modern gas cutting practices. Cutting no longer is simply cutting—it has many diversified applications. It is quite possible to use cutting unwisely or to employ it inefficiently. Engineering study and in-

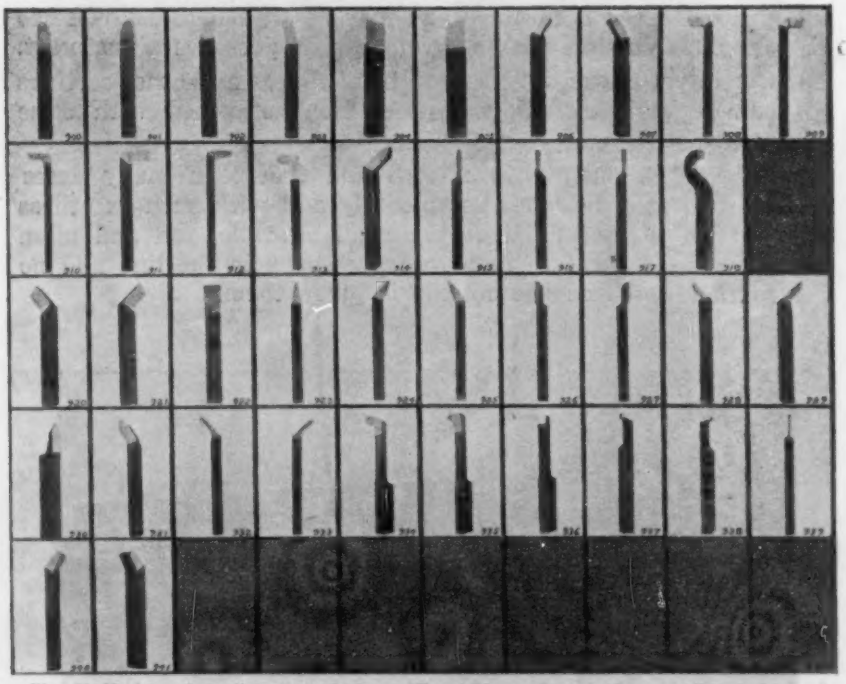


Fig. 27—Variety of small tools made by welding high-speed steel tips to ordinary shanks by resistance butt welding.

telligent supervision are as necessary for the success of gas cutting as for other activities of the railway or industrial plant.

RESISTANCE WELDING

Resistance welding is used in the manufacture of many articles we use every day, including the welding of the stems in watches, the rims of our eye-glasses, the handles of knives and forks, the rims and frames of our baby carriages, our automobiles, rims for truck wheels, handles on wrenches, chisels and hayforks, shanks of mild steel on high speed drills, reamers and cutters, chains for all purposes and of all sizes. The term, "resistance welding" applies to seam welding, spot welding and butt welding.

Seam welding has now been devoloped so that two ⅛" sheets may be successfully welded and the length of seams can be practically anything that can be secured in commercial stock. It can be applied to the manufacture of steel barrels, casks, tanks, culverts, smoke stacks, ventilators, conveyor tubes, heating and ventilating pipes, etc.

The seams can be made at the rate of 40 feet per minute on two

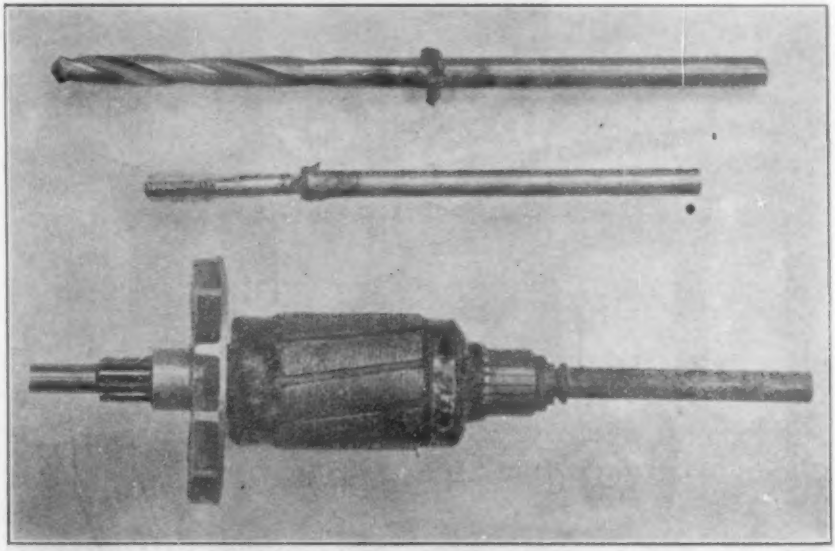


Fig. 23—Drill tap and armature shaft welded by Resistance Welding Process.

1/16" sheets and 20 feet per minute on two ⅛" sheets without any scarfing or special preparation of stock.

"Spot welding" machines have now been developed that are entirely automatic as regards time and pressure so that the welder functions in the same way each time, and makes all welds alike. Some recent applications of spot welding are welding the outer edges of disc wheels for automobiles, reels for moving picture films, smoke stacks, ventilator pipes, and ventilator covers for ships, automobile bodies, motorcycle sidecar bodies, pressed steel automobile wheels and many forms of cooking and household utensils. The welding of spacers to thin iron laminations for induction motors are now made by the semi-automatic spot welding machine, resembling a sewing machine. One electrode is stationery while the other slides on a carriage which is moved up and down by a revolving cam. A coil spring between the electrode and carriage insures uniform pressure of the work piece and the speed of the cam is such that the electrode is in contact with the work just long enough to secure good fusion of the pieces, probably one or two seconds. A commercial spot welder has now been developed for welding two ½ inch plates.

Through the application of butt welding, steel castings or complicated machine parts are being replaced by either drop forgings or steel stampings in halves and welding these halves together by the resistance method. By this procedure great uniformity of product and light weight may be obtained and while retaining or improving the quality, articles so manufactured can be produced

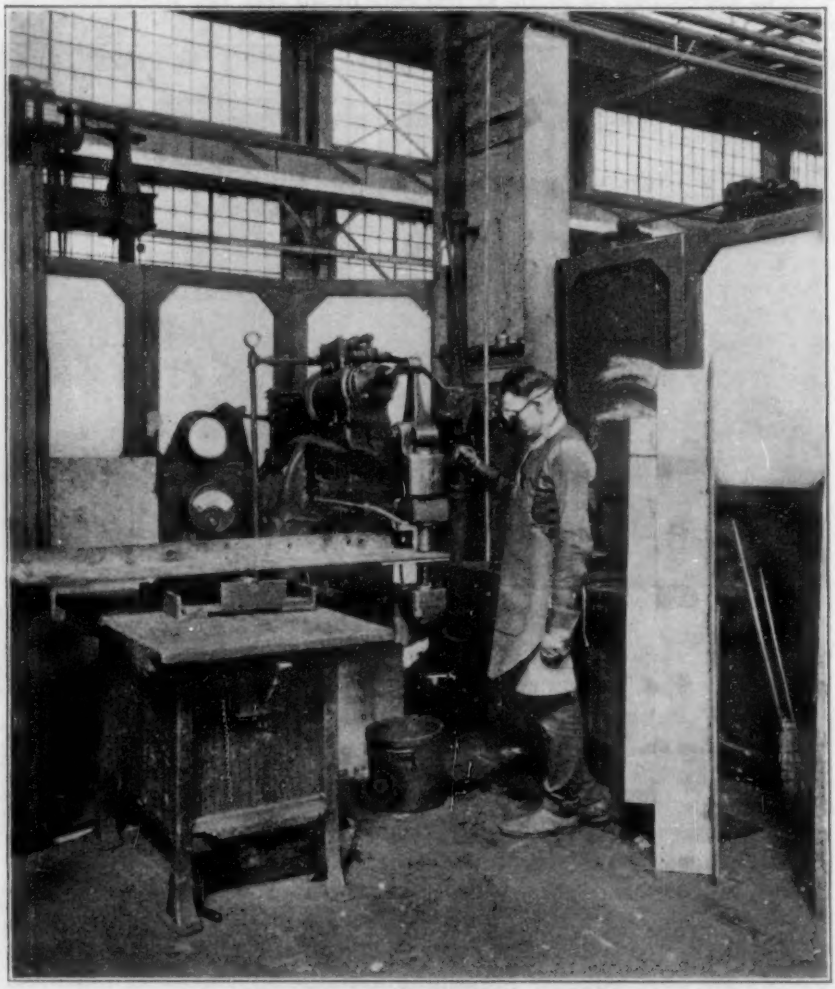


Fig. 24—Heavy Spot Welder welding two ½ inch plates.

cheaper. The Metropolitan Engineering Company of Brooklyn are manufacturing among other products, welded rear axle housings for automobiles, which housings have welds 24″ long (two of them total 48″) made with sheet steel of approximately ⅛″ thick.

The resistance welding is distinguished from other welding processes in that it is used particularly for mass production of

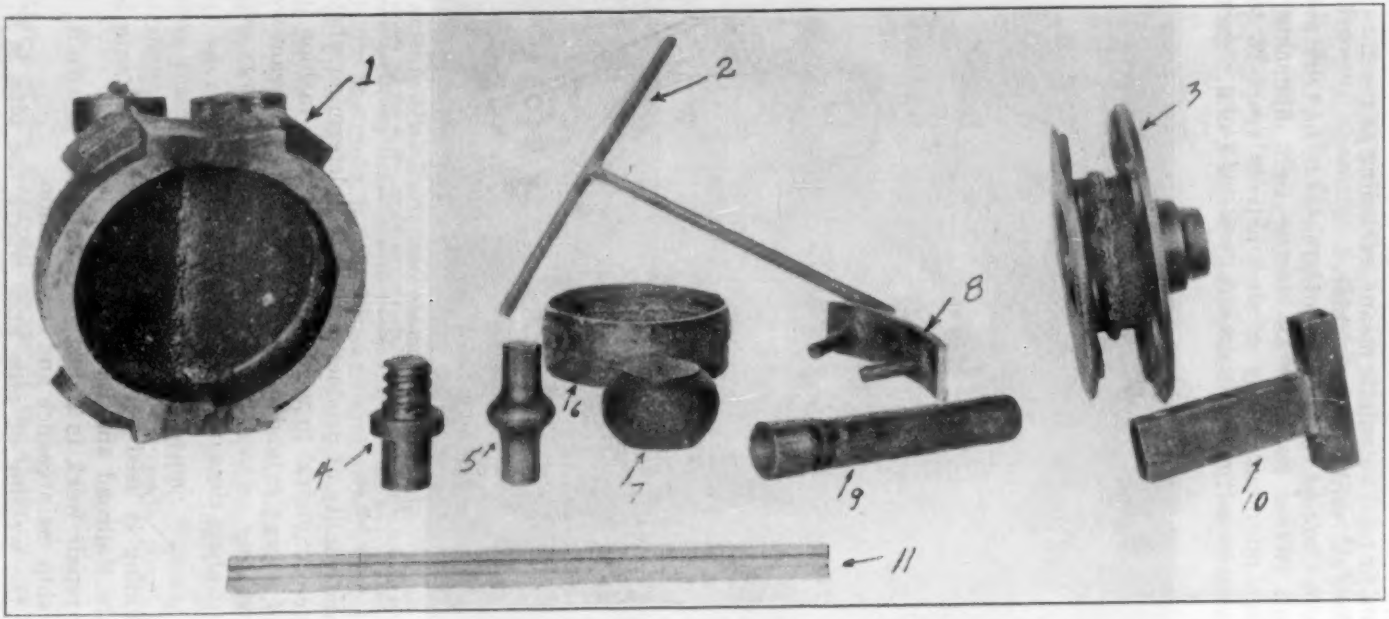


Fig. 25—Examples of Resistance Welding. (1) Steel motor head made from two forgings and welded together. (2) T weld from two round pieces of machine steel. (3) Automobile wheel hub made from two frogings welded together. (4) Brass threaded piece made from No. 5. (5) Round stock pushed up to form a larger diameter at the center. (6) Section of locomotive superheater flue showing weld of safe end to the flue itself. (7) Machine steel heated and pushed up to show expanded diameter. (8) Machine steel studs welded to a machine steel bar. (9) Cupped drawing welded to machine steel head. (10) Two pieces of tubing welded in T shape. (11) 12" rule to show comparative sizes of pieces.

standard articles to be brought to welding machines to be welded, mostly by semi or total automatic means, excluding as much as possible the individual skill of the operator.

The range in size and composition of articles to be thus welded is very great. Wires as small as electric light filaments can be welded as a minimum. Iron or steel articles from 16 to 20 square inches cross section are successfully welded as a maximum

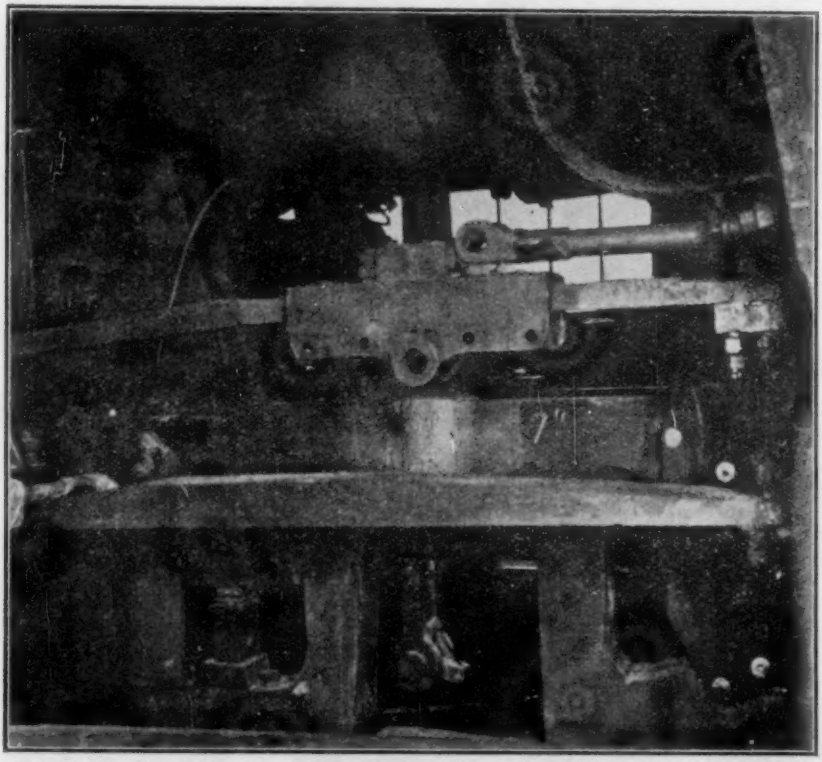


Fig. 26—Thermit weld on a typical 7" x 7" locomotive frame. The excess metal at the joint is used to obtain proper fusion of the interior and of the extreme fibres, and is not for the purpose of reinforcing the weld. It can, therefore, be machined off with perfect safety, but where it does not interfere is usually left on.

and the size and quality of product desired will determine whether it will be more economical to weld in a step by step fashion by a small amout of energy extended over a long time as in seam welding and spot welding, or to apply a large amount of energy over a great area for a short time only.

THERMIT WELDING

Thermit welding is used very extensively as follows:

A: In the Railroad and Railway Field.
B: For repair work in industrial plants.
C: For ship maintenance and construction.
D: For the welding of pipe lines where the pipe is 6" in diameter or less.

General

Broadly speaking, a thermit weld is made (after cutting a small gap at the fracture) by surrounding the broken ends with a sand mold, and pouring between and around these fractured ends thermit steel. This thermit steel is a very high grade, pure steel, having rather the properties of forged steel than of cast steel,

Fig. 27—Pouring the thermit rail weld. The thermit steel has just been tapped into the mold. This thermit steel was generated in the small crucible in about 15 seconds after igniting the thermit. On the right can be seen the kerosene and air preheaters by which the rail ends are heated and the mold dried out prior to pouring the thermit weld. In this particular case, two single burner preheaters are being used, whereas usually one double burner preheater is used.

and it is created in less than one minute by placing an amount of thermit in a crucible and igniting it locally. The steel is made so quickly that its temperature is almost double that of ordinary molten steel, so that immediately after reaction, when it is tapped into the mold, it falls between and around the fractured ends, gives up its surplus heat to these ends and solidifies with them in a strong, solid, homogeneous weld.

Thermit welding has a field of its own in the heavier steel and cast iron repairs, such as armature shafts, crankshafts, frames and heavy parts of machines, rolling mill pinions and rolls, locomotive frames, yokes, pedestals, etc., stern frames, rudder stocks and similar parts of vessels, street car rails, frogs and crossings, and pipe lines of 6″ diameter or less.

A. Railroad and Railway Field:

Many of the Railroad Shops of the Country are using thermit welding for the repair of their locomotive side frames, guide yokes,

etc., and this probably is thermit welding's largest field. The frames run from the smaller ones (say, 4″ x 4″) to heavy sections 8″ x 8″, and when the fracture has been made accessible, a repair of this kind can easily be completed in an eight hour day. Usually, the repair can be made without the removal of any parts of the locomotive unless these are quite close to the fracture; and the locomotive is, therefore, repaired and returned into service in a minimum length of time.

To one not familiar with railroad work, it would not seem that these heavy frames break very often, but the parts crystallize

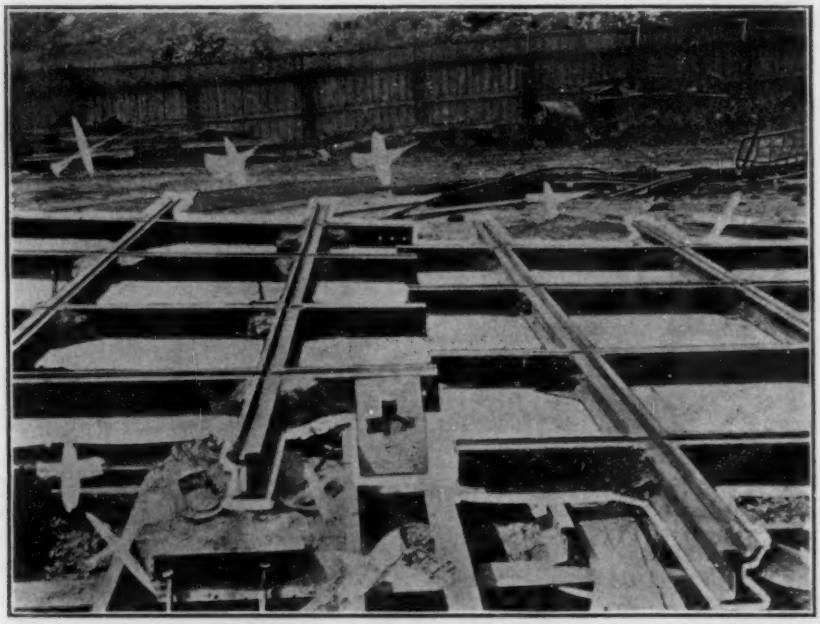


Fig. 28—Crossings constructed by means of thermit welding. In this work, short lengths of rail are cut and fitted together and thermit welded at their intersections. Those crossings shown are comparatively simple, whereas in some of the Milwaukee installations numerous complicated layouts have been made. Such a construction has the advantage of low cost, prompt delivery, and can be made up in small units and thermit welded together in place, thus simplifying transportation while still eliminating joints. In the crossings shown, the molding sand has not been cleaned away from the intersections so that the thermit welds themselves are not visible.

and fatigue rapidly on account of the great vibration, racking and pounding in operation. Many Railroad Shops have extended the application of thermit welding to the remodeling of locomotives, welding in heavier pieces to replace parts of frames which have proven weak, or welding extensions on frames where the design of leading truck or cylinder support is to be changed. One railroad, for instance, having found that its Santa Fe type of locomotive developed a weakness in a certain part of the heavy side frames, took all of its locomotives of this class, cut through the

frame at this point of weakness and thermit welded this point in a way to re-enforce the frame.

The growth of thermit welding in the street railway field has been very marked, and has attracted wide-spread attention. By means of thermit welding, the Maintenance of Way Departments

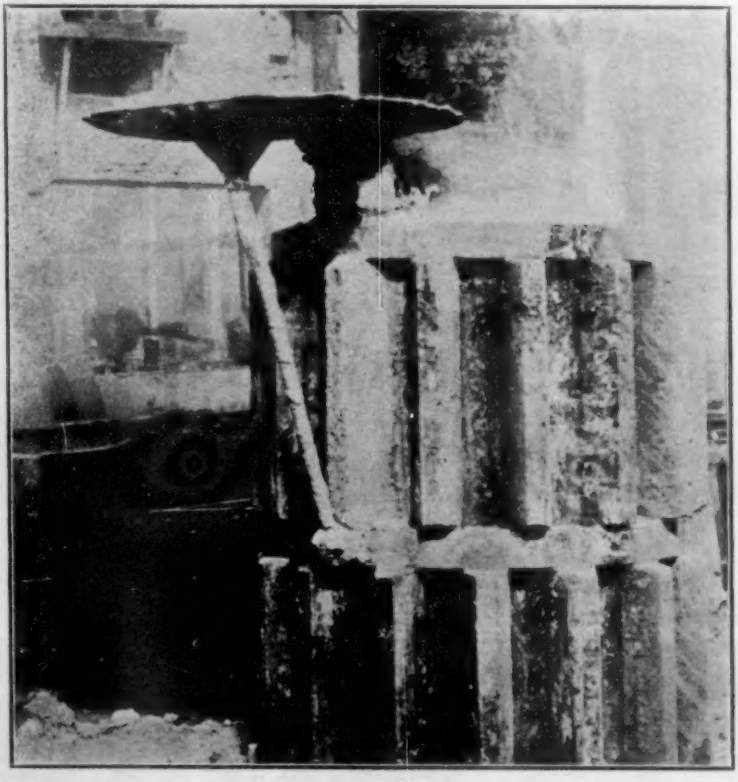


Fig. 29—Large rolling mill pinion with broken tooth replaced by thermit steel. Hundreds of repairs of this kind have been made in the steel mills.

have thermit welded the street railway tracks making the rails continuous and eliminating most of the troubles due to joints. Street Railways also use the thermit weld in the construction of frogs and switches made by setting up rails, cut and formed to the proper length and shape, and thermit welding the intersections. Thermit welding is also used by the Rolling Stock Departments of Street Railways for the repair of truck frames, motor cases and similar work.

B. Repair Work in Industrial Plants:

Most people are probably familiar with some of the numerous thermit repairs made in industrial plants and steel mills, such

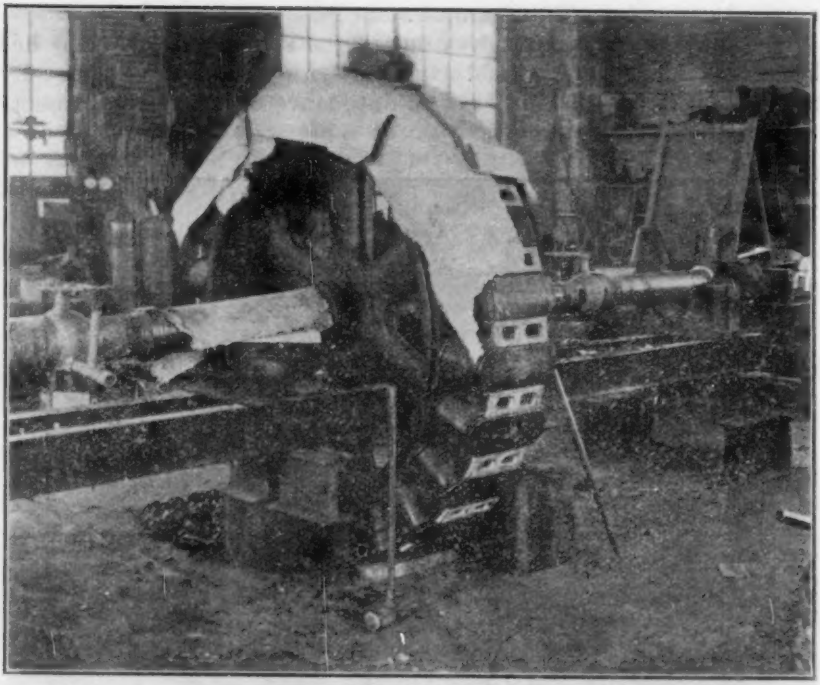


Fig. 30—Two thermit welds, one of each end of large revolving field generator shaft. It will be noted that oversize billets were welded into place and these will be subsequently turned to the original diameter. Much work of this nature is being done to replace scored or worn journals, or to reconstruct and extend journals to suit redesign of bearings and supports.

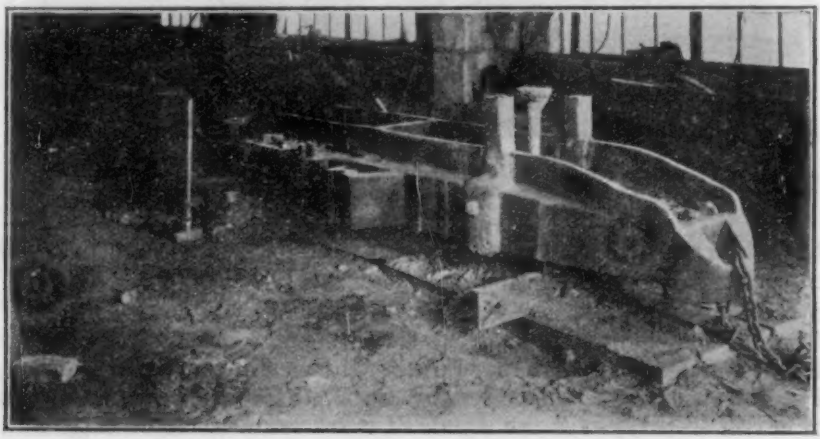


Fig. 31—Thermit weld in large cast iron press side frame for Leonard Sheet Metal Works, Hoboken, N. J.

Thermit welding lends itself to the repair of such cast iron sections admirably because the weld is all made at one time and consequently the shrinkage is absolutely uniform. The pouring gates and risers are cut off with the oxy-acetylene torch and in many such repairs, the excess metal in the thermit collar is left on as it acts as a reinforcement, although its original purpose was to furnish sufficient heat to cause thorough fusion of the interior and of the extreme fibres.

as—for instance—the replacement of broken teeth in large steel pinions, or the repair of worn or broken roll necks, pods, the repair of broken machine parts, such as, crankshafts, cast iron or steel machine frames, etc. This thermit welding work in the steel mills and larger industries is usually handled by their own welding departments in the regular course of their work, but many of the smaller plants have these repairs made in outside shops

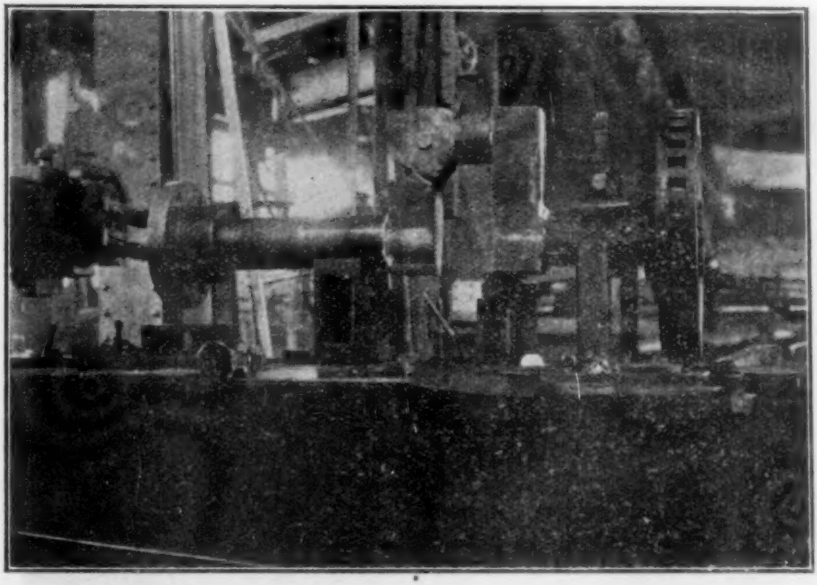


Fig. 32—Single throw crankshaft thermit welded at the junction of the pin journal and web. In such a case, all the excess metal is machined off. Many hundreds of such thermit welded shafts are in operation.

equipped for thermit welding, and in these shops repairs are made of numerous press frames, armature shafts and crankshafts varying in size from small pieces weighing 100 lb. or so to large press heads and similar parts weighing 30 to 40 tons. All of this work is usually of an emergency nature and such welding shops are usually prepared to work night and day.

C. Ship Maintenance and Construction:

Thermit welding has found a very broad field in ship repair work on account of the very frequent occurances of broken stern shoes, stern frames, etc. These sections are usually either forged steel or cast steel, and although some of the lighter ones on tugboats and small craft may be 2″ x 4″ in section, the frames of such large ships as the "Resolute" and the "President Arthur" recently repaired were about 10″ x 15″ in section.

In this ship repair work, the replacement of a broken stern frame is, of course, an enormous undertaking, costing $30,000

to $50,000 with Dry Dock charges in the neighborhood of $700 to $900 per day. A thermit weld can be completed in two or three days on even these heavier sections where the welding must include the erection of scaffoldings, etc., so that the saving is obvious. The ship yards have found thermit welding very useful in the replacement of worn rudder stocks. These are usually from 8″ to 15″ in diameter, and when worn in the bearings, the stock is cut

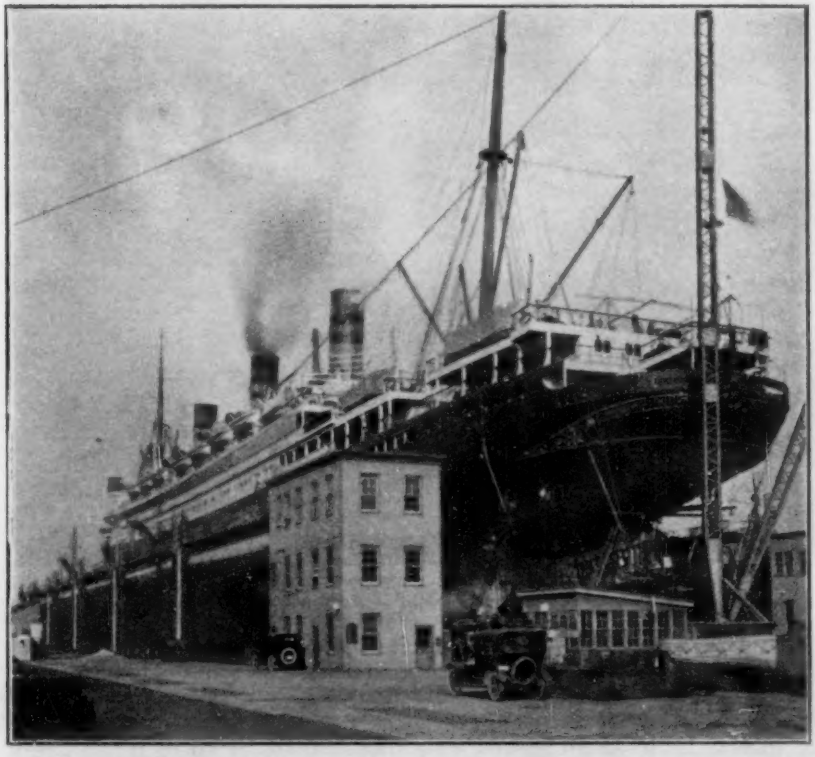


Fig. 33—Repair of stern frame of S. S. Resolute. Although this is one of the largest of the recent ship repairs, it is nevertheless typical of this class of repair. Hundreds of similar broken stern frames have been thermit welded and not a single one has failed. This photograph shows plainly how much of the plating had to be stripped from the stern frame to make the broken parts accessible.

off, leaving the rudder itself intact, a new stock machined and welded into place.

D. Welding of Pipe Lines:

The welding of pipes or tubes by means of thermit is an application quite different from the ordinary thermit weld. In the performance of this work, the ends of the pipe are faced and butted together with a clamp on each. Two turn buckles or screws are provided so as to enable the operator to draw these clamps and, therefore, the pipe ends tightly together. The joint is then

surrounded with a simple, two part, cast iron mold, an amount of thermit reacted in a flat bottom crucible and immediately after reaction the molten mass poured into the mold. This molten mass surrounds the pipe at the joint, and within a minute or so, brings this pipe to a welding heat, when the operator tightens on the screws or turn buckles, forcing the pipes together about ⅛" and thus causing a strong butt-weld at the joint. Upon removal of the clamp and mold, the solidified thermit steel and slag drops away from the pipe and the weld is completed. Such pipe welds

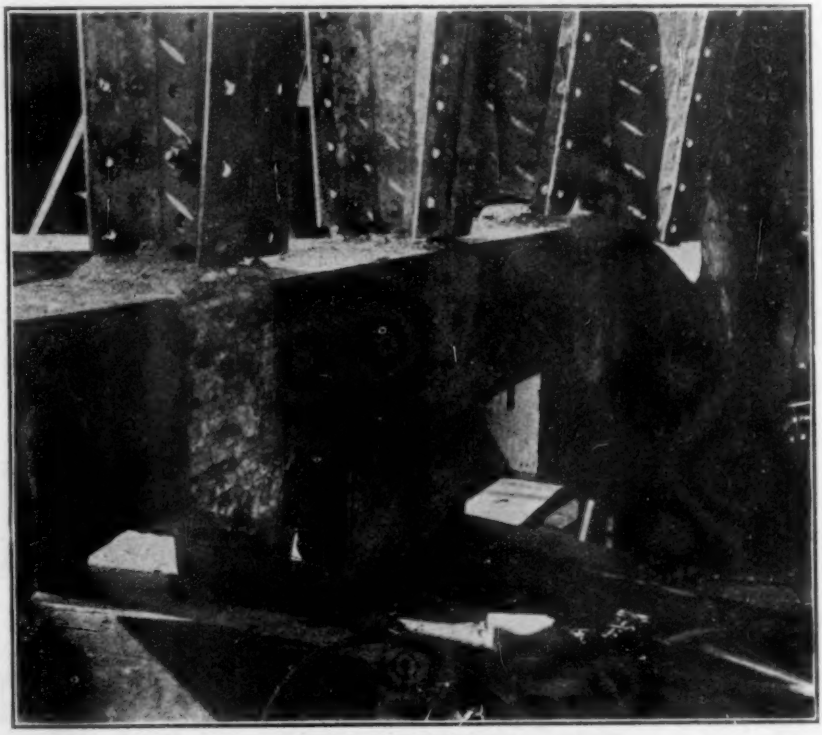


Fig. 34—Close-up view of the two thermit welds in the broken stern frame of the S. S. Resolute. This frame was 10" x 15" in section and there was really only one fracture about midway between the two present thermit welds, but the metal in the neighborhood of this fracture was evidently defective so that a new forging was made, machined and drilled, supported into position, and welded into place by means of the two thermit welds. This repair was made shortly before the S. S. Resolute went on her "Around the World" cruise last January.

invariably test stronger than the pipe itself because the metal is upset slightly at the joint and the section is, therefore, heavier. This upsetting, however, is all outward so that the interior of the pipe remains straight and smooth, and in no way is the flow of air or liquids through the pipe restricted. Pipes thus welded may be formed or coiled, and all of the trouble from the usual threaded joint and fitting eliminated.

The apparatus for thermit pipe welding is very simple. The pipes may be faced in a lathe, or a special machine designed for this purpose and operated by hand may be used. Only two sizes of clamps are necessary for the entire range of pipes from ½" diameter up to 6" diameter. The small cast iron mold for each size of pipe is plainly marked, the thermit welding portion also plainly marked, and just the proper amount furnished for each weld. This amount of material, if poured into the mold im-

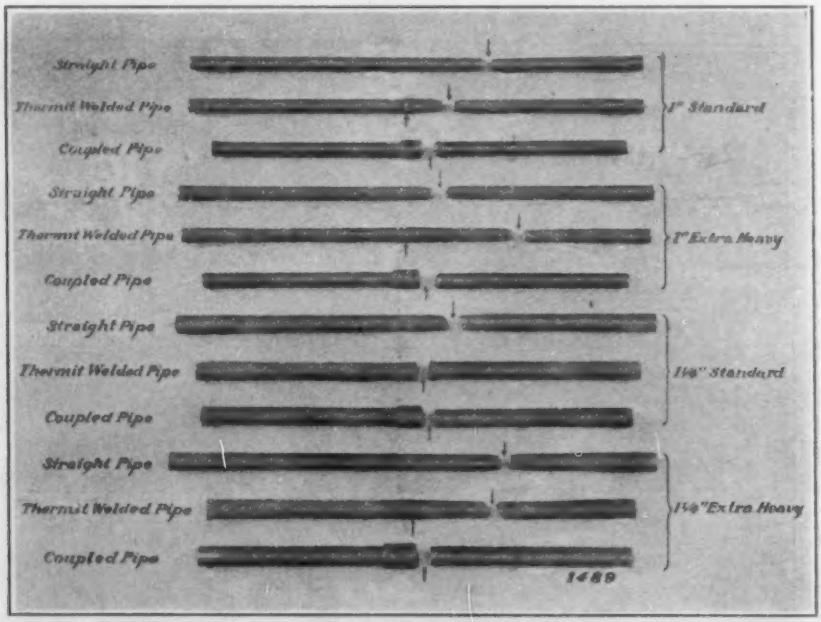


Fig. 35—Tests on Pipes.

mediately after the reaction, is bound to give just enough heat to thoroughly weld the pipe ends together so that there is little that an operator could do which might have any bad effect on the strength of the weld. Two men in open trench work should easily face and make thirty welds per day, and the apparatus has the advantage of lightness, portability and requires no outside power.

CONCLUSIONS

The foregoing report covering some of the industrial applications of welding, gives a clear picture of the extent and importance of these applications at the present time. One fact which stands out clearly in this picture is, that, taken together, the several welding methods for the study and development of which this Society was organized, constitue one of the most important, far-reaching and labor-saving processes ever invented.

Moreover, when you consider the shortness of the period during which most of this development has taken place, and that the most rapid development has taken place since the birth of our Society, we should be proud of our share in a real service to the industries of this country and of the civilized world.

But what of the future, for we have only just begun a work the possibilities of which are boundless. Take for example the field of steel structures, which alone offers an opportunity for welding far exceeding that of the present applications taken together. Why has not more progress been made in this field?

The answer is simple—we must first prove that welding is better or cheaper or both. This means demonstration on a commercial scale. Some little start has been made with oil storage tanks in this country, with gas-holders in Australia, and with small steel vessels; but the field of steel buildings is practically untouched, particularly as regards the possibilities of spot welding, and full information as to cost as well as design and procedure is lacking in the small experimental structures already built.

What we need is more thorough and comprehensive cooperation, and the only organization available for that purpose is the American Welding Society. We cannot expect a single builder to take the risk of failure and to bear the cost of developing the technique of welded construction; there must be cooperation between the builder, welding expert and the welding industry.

RELATIONS OF THE SOCIETY TO THE INDUSTRY

T. F. BARTON, *President.*

The American Welding Society was organized in 1919 to provide united co-operative action in extending the knowledge of the art of welding and its field of industrial application. The possibilities of the use of welding are now being recognized by the industrial world and consequently new applications are brought about daily. These new applications require sound scientific knowledge as to proper technique and procedure.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections an opportunity is provided for the exchange of information and the benefit of the combined knowledge and experience of all members of the Society is made available to everyone. As a result, costly mistakes may be avoided. Successful experiences in other fields may, with slight modifications, be applied in solving new problems. The prospective user of welding is not handicapped by the confusing and opposing claims of competing interests as reliable authentic information may be obtained from the Society.

In some cases knowledge as to proper technique and procedure is not always available. Moreover in many cases where human life and property depends upon the reliability and strength of the weld it is necessary to provide satisfactory regulations and codes. Tests must be devised to determine whether a consrtuction is safe for the purpose at hand. Through its research department (the American Bureau of Welding), the Society is supplying this information to the industry at a minimum cost. This exchange of information and co-operative effort has enabled the welding industry to advance in months what normally would have taken several years of individual effort, with a consequent saving of hundreds of thousands of dollars. Through its successes and through the fact that it has affiliated with it the foremost welding talent in the world, the Society has inspired the confidence of some large national organizations and leaders in industry. Its research department, for example, is closely affiliated with the National Research Council. It has either under way or successfully completed joint undertakings with such organizations as the American Electric Railway Association, The American Society of Mechanical Engineers, Federal Board for Vocational Education, The American Institute of Electrical Engineers and the American Society for Testing Materials. These undertakings will be described in greater detail in the "Technical Work of the Society" by W. Spraragen, Secretary of the American Bureau of Welding.

In conclusion, I wish to point out that the American Welding Society is now recognized as the most authoritative source for welding information in the world. No one who has any interest in welding can afford not to be affiliated with it.

TECHNICAL WORK OF THE SOCIETY

W. SPRARAGEN, *Secretary, American Bureau of Welding.*

The American Bureau of Welding is the welding research department of the American Welding Society and the National Research Council. It is organized to provide the welding industry with the means for solving the many difficult problems arising in the art of welding and its applications on a co-operative basis and at a minimum cost. Most of its work is accomplished through eleven research sub-committees which are working on various problems as indicated by their titles: Electric Arc Welding, Gas Welding, Resistance Welding, Thermit Welding, Standard Tests for Welds, Welding Wire Specifications, Specifications for Materials to be Welded, Training of Operators, Welding of Storage Tanks, Welding of Pressure Vessels, Welded Rail Joints.

A large number of reports have already been published which are recognized as authoritative both in this country and abroad.

It would require too much space to describe these reports in detail. Several examples, however, are given below as indicative of the kind of work undertaken by the Bureau.

Standards for arc welding and resistance welding apparatus have been prepared. The rules include classification, definition of terms, information relative to apparatus to be supplied by the manufacturer and by the prospective purchaser, respectively, methods of testing and rating. A summary of the "Present State of the Art of Welding Cast Iron," including the best existing information and methods of procedure and results of tests, has been published. Critical reviews have also been made of existing information on the application of arc welding to ship construction, various forms of resistance welding and gas welding of pipes. Specifications have been drawn up as to the chemical analyses of welding wire to be used for welding various materials. A number of experiments have been made to investigate methods which were proposed for distinguishing between suitable and unsuitable materials to be welded. With the co-operation of the Federal Board of Vocational Education, standard training courses have been prepared for the training of gas and electric welders. To overcome the difficulty now experienced in the riveted tank used for holding light oils, specifications have been drawn up for the welding of these tanks. The result of this application of welding promises not only a cheaper, but also a better storage tank and opens up a new and large field to which welding is particularly adopted. Several small tanks have already been successfully built in this way, although the designs were not especially adapted to welding. It is estimated that the saving which will be effected by the prevention of loss of oil from evaporation and leakage will pay for the welded tank inside of two years.

One of the many difficult problems concerning the Boiler Code Committee of the A. S. M. E. in its effort to draw up satisfactory codes governing the construction of unfired pressure vessels is welding. Rules applicable in riveted construction do not always apply to fabrication by welding. The problem was seriously complicated because of the meagreness of scientific data on which to place proper requirements of safety without placing unjust restrictions on the use of welding. Wide differences of opinion prevailed not only amongst members of the Committee, the insurance companies and the inspectors, but also in the industry itself. To meet this need the Bureau undertook a co-operative investigation which involved some $15,000. Forty tanks were tested to destruction by the Bureau of Standards under the direction of a suitable committee. As a result of the data obtained from such tests it was possible to draw up proper rules governing the use of welding in the construction of unfired pressure vessels and also proper tests for the finished tanks.

The welded rail joint problem is a vital factor with the street railway companies as thousands of joints are being installed each year by the street railway companies who are in many cases using methods and variations in practices which have been tried elswhere and found unsatisfactory, or the ultimate effects of which are entirely unknown. The American Electric Railway Association, The Amercian Welding Society and National Research Council united in an authoritative investigation on the various types of welded rail joints in commercial use. The work outlined in the program developed by the Committee involved a sum on the order of $80,000. Co-operation has been offered from all sides. The rail manufacturers furnished rails for testing purposes, electric railway companies and joint manufacturers made joints for testing, U. S. Bureau of Standards, Purdue University and University of Illinois are supplying laboratory facilities. About $24,000 in cash has been placed at the disposal of the Committee by the A. E. R. A. and a number of the larger street railways. Two testing machines have been designed by the Committee and one of them, the repeated impact testing machine, has already been built. This machine will give the test joints repeated impact blows of a magnitude equal to that struck by a street car passing over a "cupped joint." Testing has already been started and the work of the Committee is well under way.

Aside from the specific investigations undertaken by the Bureau, it is also supplying information on welding in answer to numerous requests received from all parts of the world. Some of these relate to proper technique to be employed and specific applications of weldnig. Others are requests for information as to available apparatus, test results, literature, etc. Still others deal with the possibilities of the application of welding in certain fields. To all of these the officers of the Bureau have, with the assistance of its committee members, been able to give satisfactory replies.

The Bureau fills the need for an agency whose pronouncements may be looked upon as authoritative and without commercial bias.

BRITISH CAST IRON ASSOCIATION REPORTS ON WELDING

Note: The following two articles are taken from the January, 1923, Bureau Bulletin of the British Cast Iron Research Association, under the heading, "Summary of Reports Upon Inquiries to the Bureau."

Welding Malleable Castings

In preparing the work for mending, the fracture is chipped away in the form of a V groove with the pointed bottom just coming to the surface on the opposite side, or, if the casting is thick and the opposite side accessible, two grooves are cut with their pointed bottoms meeting in the center. The part surrounding the fracture is then heated with an oxy-acetylene torch to a bright red, and sprinkled with bronze flux followed by a few drops of bronze melted from the welding rod. If the bronze remains in a little globule the work is not hot enough, but if it spreads and adheres to the surface, the temperature is right, and the groove should be quickly filled. It is not advisable to keep the work hot any longer than is necessary, but to make the mend as quickly and at as low a temperature as possible. The behavior of the bronze affords a guide in regulating the temperature. This process cannot be called authogenous welding, but a malleable casting mended in this way is practically as good as one piece. It has about the same tensile strength and ductility as the original and the process has the advantage of being very quickly performed.

Oxy-Acetylene Cast Iron Welds

For iron castings the parts should be prepared by cutting way the edges to be welded to an agle of 45° on each side to permit the operator to start at the bottom of the broken section. It is also usually best to place the casting in a rough brick enclosure so the heat may be properly confined. Silicon in cast iron tends to promote the formation of graphite making the iron soft. Manganese and sulphur, on the other hand, have the opposite effect. Cast iron welding rods, therefore, should be high in silicon and the grade of iron used must be the best. The rod must be cast in a heated metal mould in such a manner that it is free from sand and is not chilled on the surface. Use of welding rods low in silicon and high in manganese and sulphur tends to produce white or chilled iron containing no graphite carbon, making the weld intensely hard. The manufacture of good welding rods cannot be carried out in the ordinary foundry, as the iron is not suitable for the purpose. Use of a small quantity of flux is also effective.

Current Welding Literature

Applications of Arc Welding to Ship Construction, E. H. Ewertz, Marine Engineering and Shipping Age (July, 1923), Vol. 28, pp. 420-4 and 440. Original iron ship construction, welding would give ideal condition, the AC-1320, the 1,200 ton oil barge Hisco, the Fullagar.

Arc Welding, Royal Mattice, Engineers and Engineering (April, 1923), Vol. 40, pp. 91-8. Definitions, stresses and strains.

Arc Welding Gas Holders, J. N. Reeson, Welding Engineer, Vol. 8 (Sept., 1923), pp. 25 to 28. Advantages of new method of construction. Description of new gas holder and design of extension wall.

Autogenous Welding, A. W. Young, Railway Journal, Vol. 29 (Sept., 1923), pp. 21 to 22.

Autogenous Welding of Aluminum and Aluminum Alloys, A. Eyles, Metal Ind. London (July 6, 1923), Vol. 23, pp. 2-3. Fluxes for autogenous welding, applying flux, welding rod, preparing the metal to be welded, preheating, execution of welds, advantage of puddling method.

Autogenous Welding of Broken Aluminum Castings, Mech. Weld. (June 15, 1923), Vol. 73, pp. 375-6.

The Effect of Gases in Steel on Welding, L. Jordan, Forging, Stamping and Heat Treating, Vol. 9 (Aug., 1923), p. 349.

Electric Welding, E. Delamarre and G. Levy, 80 pages, 149 figures, cost 10 francs, 37 Quai des Grands-Augustins, Paris. General rules applicable to different metals, processes of welding by electric arc, technique of each process, examples, solution of problems, electric and resistance welding.

Electric Welding and Cutting, Safety In, D. H. DeYoe, National Safety News (July, 1923), Vol. 8, p. 39.

Frame Making and Repairing, Railway Mechanical Engineer (Sept., 1923), Vol. 97, pp. 648-650. Discussion on frame welding.

Gas Welding and Cutting, Safety In, C. F. Worfolk, National Safety News (July, 1923), Vol. 8, pp. 38-9.

Gas Welding in City Gas Plant, R. E. Lundgren, Welding Engineer, Vol. 8 (Sept., 1923), pp. 36 to 38. Underground steel main construction, welded pipe and extra heavy flanged steel, valves with welded companion valves put end to leakage.

Generators Withstand Fire, B. K. Smith, Welding Engineer, Vol. 8 (Sept., 1923), pp. 22-3.

Metallurgical Aspects of Welding, L. Aitchison, Acetylene Journal, Vol. 25, (Sept., 1923), pp. 129 to 142.

Oxy-Acetylene Process of Cutting Metals, Machinery, N. Y. (July, 1923), Vol. 29 pp. 857-9. Advantages of this method and some modern applications.

Pipe Welding and Fittings, Welding Engineer, Vol. 8 (Sept., 1923), p. 19. Usefulness of welding to electric companies, efficiency of welded joints, economy of this method.

Repairs to J. D. Archibald, Pacific Marine Review (Sept., 1923), p. 431.

Welding Cracks in Side Sheets, R. P. Palmer, Welding Engineer, Vol 8 (Sept., 1923), pp. 32-3. Methods used by four experts.

Welding in Petroleum Industry, R. B. King, Welding Engineer (Sept., 1923), pp. 20-1. Selection of welders, material used and welding applications in this field.

Welding Small Tanks by Oxy-Acetylene Processes, Acetylene Journal, Vol. 25 (Sept., 1923), pp. 117 to 124.

Trade Catalog—Electric Arc Cutting and Welding Company issues a 52-page catalog containing a description of their apparatus and valuable technical information and illustrations of difficult welding jobs.

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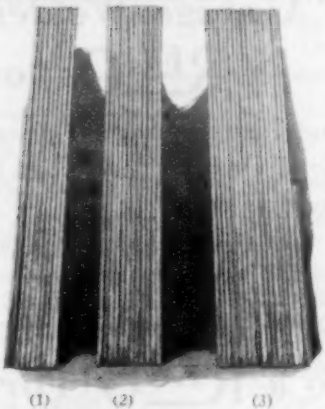

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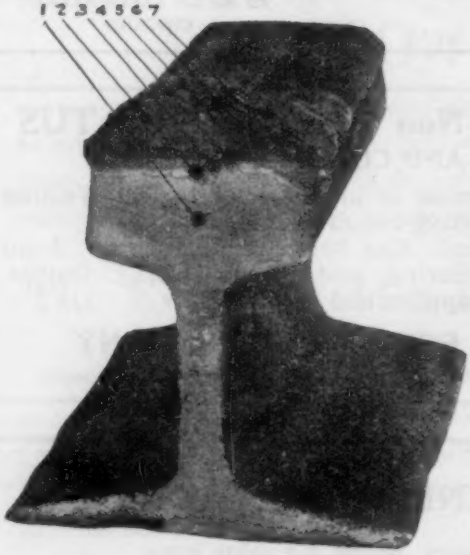

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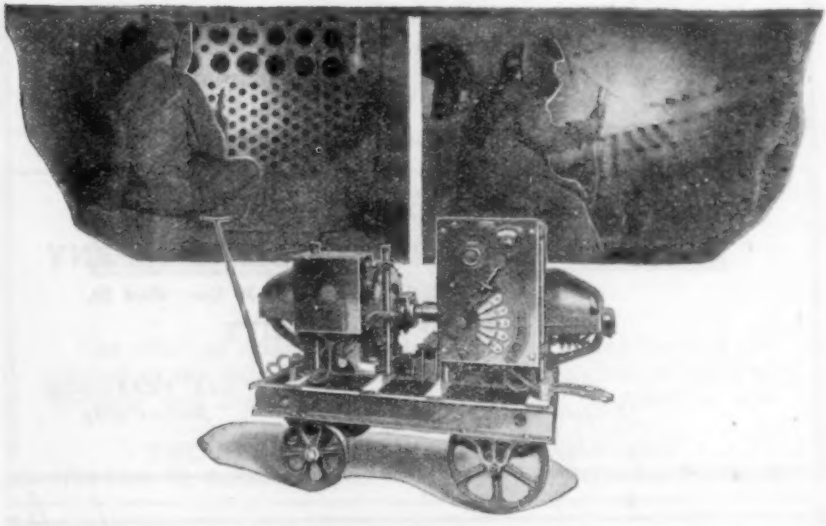

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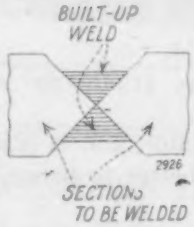

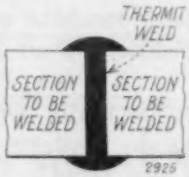

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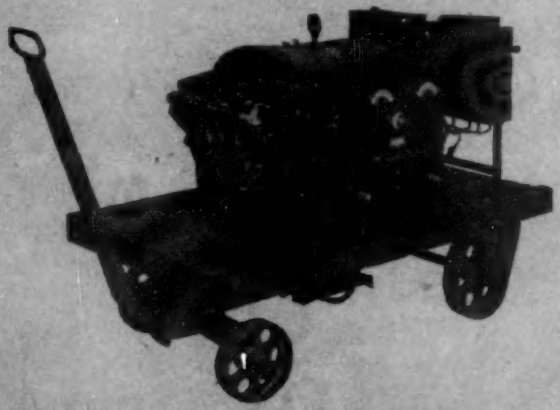

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